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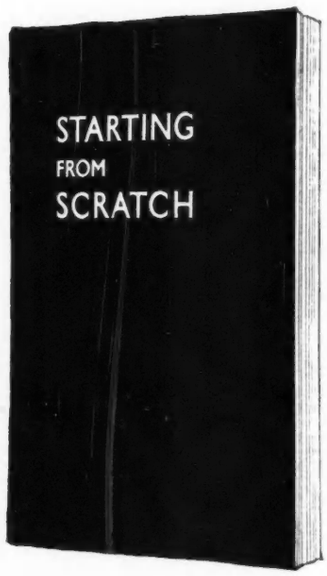

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THE STORY OF ATOMIC ENERGY.

I.—ALCHEMY TO CHEMISTRY.

By Dr. FREDERICK SODDY, F.R.S.*

THE story of atomic energy proper, as distinct from molecular energy, belongs almost wholly to the Twentieth Century, and will be begun in the fourth part. In this, and the following two parts, a brief historical survey is attempted of the conceptions and conclusions arrived at, up to the end of last century, concerning the nature of matter, electricity and energy in general, and with regard to the atom and molecule in particular.

It has been helpful to the writer, and may be to the reader, to try to trace anew the origins in the past of our present ideas and knowledge up to the

FIG. 1. OUROBOROS, THE TAIL-EATING SERPENT OF THE ANCIENTS.

point they had reached when atomic energy was first discovered. With the whirligig of time, past history takes on new complexions and this is no less true of what is commonly accepted as the past history of the physical sciences. The contemplation of its kaleidoscopic changes may enable the general reader the better to evaluate the tremendous significance of the outstanding achievement of the present century with which the rest of the book is concerned, for in the long view and last analysis, the history of science precedes and moulds the history of man.

As all the world knows, the story has culminated in the production of the atomic bomb which ended so summarily the Second World War, 1939–45. This was the technological first-fruit of knowledge actually only won for the first time during the progress of that war. Then it became possible by human artifice to liberate atomic energy on a large scale by contriving the spontaneous break-up of the atom, the very name of which means the indivisible. Whereas the forms of energy from which, whether in peace or war, all life—and, indeed, practically all forms of terrestrial liveliness, animate or inanimate—derive their motive power, arise from changes of the atom, relatively quite superficial. These changes, by comparison so easy to produce, control and reverse, concern only the electrical outworks of the atoms rather than the material stuff of which they are built up. As the ordinary physical and chemical changes that matter undergoes, they are, perforce, familiar enough to everyone from birth, however little they may regard themselves as among their most astonishing examples and however little satisfactory they may regard the efforts of science to make them more intelligible.

Such accounts of atomic energy as have been given to the general public hitherto have been almost entirely by physicists, who have confined themselves wholly to the very great part their science has played. This is, perhaps, only natural as the final steps were more, or more directly, due to advances in physics than in chemistry and mathematics. On the other hand some of them who have taken practically no part worth mentioning in the work at all, have had the hardihood to re-christen radio-activity nuclear physics and atomic energy, nuclear energy. But it may be at once pointed out that, as far back as 1902, before physicists rightly knew what an atom is, and a decade before the rise of the present nuclear theory of atomic structure, it had been recognised that the problem of the artificial release of atomic energy, recently partially solved, was exactly the same problem as that unsuccessfully attempted from before the beginning of recorded history by the ancient alchemists, namely artificial transmutation. In the whole achievement all branches of the physical sciences have shared. It ever increasing complexity is a paradox rather than the truism it had come to appear.

No doubt the nuclear theory of atomic structure greatly assisted and accelerated the practical solution of the problem of artificial transmutation in so far as that has been achieved as yet, but it was one only of many equally necessary advances. The discovery of radioactivity and of the naturally occurring transmutation of the radio-elements, of the existence of isotopes, and of the displacement law of radioactive change, no less than the Einstein identification of mass and energy, owe nothing whatever to any particular theory of atomic structure. Moreover, it is these in particular which have made it necessary to review and re-assess the pre-Twentieth Century history of the physical sciences.

Theories come and theories go. They are adjudged in modern science pragmatically, by

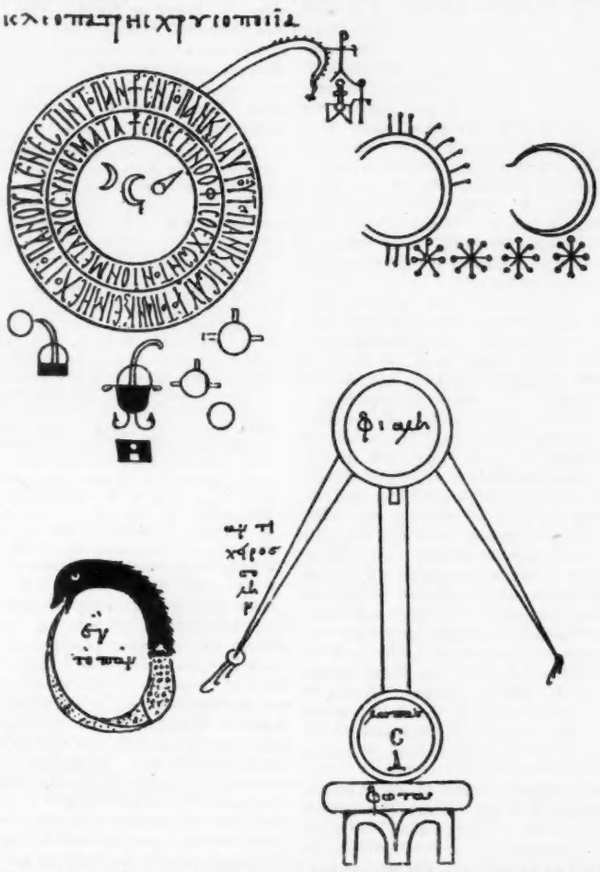


FIG. 2. CHRYSOPÉE DE CLÉOPÂTRE (GOLD-MAKING RECIPE OF CLEOPATRA).

is invidious for any one to arrogate precedence.

The writer, a chemist by original training, and, incidentally, the only survivor of the pioneers concerned with the original discovery and recognition of atomic energy, attempts in this work to trace to their origin, in correct historical sequence, all the discoveries and new conceptions which have contributed at all directly to the final result. The object has been to make the basic ideas generally intelligible, so far as that is yet possible, their detailed elaboration being pursued only as far as serves to illustrate their general novel character.

Contrary to common opinion, rather than further complication, a simplification almost unbelievable has come about in the fundamentals of the subject. It is only in the great number and variety of the atoms that complexity now enters. It would be a mistake to suppose that the subject is beyond the comprehension of any but specialists. The efforts of natural philosophers from time immemorial to reduce their world to its simplest terms are at long last being rewarded with success. That the search for simplicity should at first have led to nothing but

whether or no they lead to new knowledge; but the facts on which they are based do not change. In the following brief review of prior knowledge it has, naturally, only been possible to include the topics directly bearing on the work of this century, which appear in consequence in a new and altered light.

THE ORIGINS OF CHEMISTRY.

The origins of chemistry are hidden in the mists of antiquity. The word *chemia* came into use in the Fourth Century A.D., the Arabic prefix *al*, being added later. So that at first chemistry and alchemy both connoted much what the first does to-day, the subject of material changes and transformations. Though, from the first, it has been associated with the reputed art of transmuting base metals into gold and silver, this was then a natural enough deduction from the false subjective approach of the dominant Greek philosophy to the material world, which still makes havoc of "the best-laid schemes of mice and men." It was only much later, in the Middle Ages, that the word 'alchemy'

* We have arranged with Dr. Soddy to publish his new book, *The Story of Atomic Energy*, in the form of a series of articles which will appear at fortnightly intervals approximately. Dr. Soddy, however, retains the copyright; therefore no extract may be made from these articles without his permission.—ED. E.

more and more assumed the special significance it has to the ordinary man to-day, who, however, for the most part, has still to recognise it in its modern disguise as so-called "banking." It then became identified primarily with the search for the philosopher's stone, a magic talisman able to transmute practically unlimited quantities of base-metal into gold and silver, and a universal panacea, or medicine for human ailments, capable of prolonging human life indefinitely. But these ideas, again, are latent, if less definitely put forward, in early Babylonian and Chaldean, if not also in some Oriental, philosophies.

It was this curious association of ideas, that the philosopher's stone, when found, would prove a universal medicine, both for metals and for men, that by the growing concentration on the latter object brought about the downfall of alchemy. For, after an intermediate period, known as Iatrochemistry, which is what is now termed materia medica, inaugurated by Paracelsus (1493-1531), who taught that the true object of chemistry was not to make gold, but to prepare medicines, it escaped from bondage to its applications, whether technical or medical. It then became possible for chemistry to take its rightful place, along with physics and mathematics already in the full vigour of their youth, as a true science, studied primarily for the acquisition of knowledge for its own sake. This was first taught by Robert Boyle (1626-94), dubbed by a contemporary wit "Father of chemistry and uncle of the Earl of Cork," who correctly anticipated the verdict of history at least as regards the true parentage of chemistry.

From the earliest times of which there is any record, alchemy was, to us, a strange medley of a considerable body of useful chemical processes and practical methods still in use, with not only an entirely perverted theoretical outlook, but, as was natural to the times, an admixture of magical and superstitious beliefs in the influence of the stars and of good and evil spirits upon the course of chemical operations. This, in turn, led to the fraud, chicanery and falsifications which the universal belief in the possibility of transmutation and the lack of adequate methods of assaying the noble metals and detecting imitations, made both easy and profitable. In many periods of history alchemists enjoyed high Court favour as professional poisoners and debasers of the currency, succeeded by periods when they became the public scape-goat and whipping-boy for the rascalities of their employers.

There is an ancient legend that, before, and as the reason for, the Flood, the art of ennobling metals was brought down to earth by demons. Traces of this legend are to be found in the Bible, as in Genesis, VI, 1-4, but, in a greatly expanded form, the story is told in the Apocrypha, *Book of Enoch*, VI-IX.

The latter only became known to the Western World at the beginning of last century, through an Ethiopian version extant in Abyssinia, and of which no Hebrew or Aramaic text exists. It purports to be an account, written by Enoch, to his son Methuselah, of the events leading up to the Flood, which is only quite briefly referred to, and it is regarded by Biblical scholars as dating from between 200 B.C. and A.D. 100* Probably it is the work of a number of writers, who, not daring to reveal their identity, wrote under the names of the ancient prophets. It is largely an alternative version of the legend of the Fall of the Angels, as narrated in Milton's *Paradise Lost*, and tells how these descended on Mount Hermon and had intercourse with women from which arose a race of giants who turned against and destroyed mankind. These fallen angels taught their wives charms, enchantments, the arts of winning and working metals, the making of weapons, the cutting of roots, the precious stones and all manner of colouring tinctures.

By classical tradition, alchemy originated in Egypt, though no original hieroglyphic record of that epoch has been found. For one thing, it was practised as a secret art and a sacred science under the priesthood and only those of royal blood were initiated into its mysteries. So that it may for the most part have been transmitted orally rather than by writing. For another, the Roman Emperor Diocletian, after suppressing with great cruelty a rebellion at the end of the Third Century A.D., burnt all the ancient Egyptian writings concerning the precious metals, under the impression, prevalent in the outside world, that Egypt owed her wealth to alchemy, so as to prevent the country again revolting against the Roman occupation. However, the real source of Egypt's gold appears to have been the Nubian gold-mines, the word *nub* being the Egyptian word for gold.

Chemia was one of the local names of Egypt, but the word also means black (hence, perhaps, "the black arts"), while pharmacists naturally prefer to derive the name from Greek words meaning sap and infusion. By Egyptian tradition, it originated with Hermes Trismegistos (three-times-great)—hence the name "hermetic art" for alchemy, still surviving as "hermetically sealed" for a joint closed by luting or fusion. This Hermes was the Neo-Platonists' name for the Egyptian god Thoth, symbolised by the serpent-staff as the emblem of wisdom, and the nearest to Hermes, god of science and power, in Greek mythology, which makes the name "Mount Hermon" in the Apocryphal legend rather suggestive.

Fig. 1, on page 313, shows Ouroboros, the tail-eating serpent of the Ancients, signifying the unity of matter; from a Greek MS. in La Bibliothèque Nationale de Paris. The illustration is taken from M. Berthelot's *Introduction à la Chimie des Anciens et du Moyen Age*, published by Georges Steinheil, Paris, 1889. The letters *r*, *j* and *V* represent the colours *rouge*, *jaune* and *vert*.

Fig. 2, on page 313, is the Chrysopée de Cléopâtre (Gold-making Recipe of Cleopatra) from a Greek MS. in the Library of St. Mark, Venice. This illustration is also taken from M. Berthelot's work.

The Ouroboros in Fig. 1 is represented in a different style in Fig. 2, bearing the central motto in Greek, "The whole is one." The figure on the right at the bottom of Fig. 2 is a two-headed Alembic, or dibicos, used for distillation, resting on a furnace bearing the Greek word for fire, and showing liquid being distilled and dropping from the two inclined tubes. The other figures in the drawing represent magic symbols and those used by the alchemists for the metals. The symbols in the right top corner are thought by M. Berthelot to represent the transmutation of lead into silver. Cleopatra, the savant, and Mary, the Jewess, were female alchemists of the Alexandrian school at the commencement of the Christian era.

Such records of alchemy as have survived date from the Third to the Seventh Century A.D., and purport to be transcriptions and translations of Greek-Egyptian recipes and formulæ on alchemy. Many of these have been traced by M. Berthelot to a papyrus found at Thebes, where it was probably preserved in a tomb in the wrappings of a mummy, and so escaped both the Romans and the pestilential manufacturers and fabricators of history. It contains the notebooks of a charlatan magician and of a practical workman engaged in falsifying metals, and is the oldest extant, dating probably from the Third Century A.D. It is certain that at Alexandria, at the beginning of the Christian era there flourished a thriving school of alchemists, including several women, who wrote treatises on the arts of smelting and "colouring" (transmuting) metals, tinting glass and dyeing fabrics. These claimed, curiously enough, to be the disciples of the early Greek philosopher, Democritus (Fifth Century B.C.), to whom is usually ascribed the Greek atomic theory, to be dealt with later. As this is about the only connection between atoms and alchemy, and as the transmutational doctrines would more naturally derive from a continuous rather than a discrete theory of matter, probably the "disciples" would have been utterly repudiated by Democritus himself.

Ancient Chemistry.

The practical chemical knowledge of the ancients was considerable, and it was but little advanced by the subsequent 20 centuries of alchemy, least of all, perhaps, as regards the metals. Gold and silver, occurring native, have been known from the earliest times and prized for their unalterability by fire, and their malleability and ductility which makes them easy to work. The art of cupellation with lead, to remove base metals from gold, was known in the Second Century B.C., but the separation of gold and silver was not accomplished till our era. The alloy of the two metals, called *asem* by the Egyptians, and *electrum* by the Greeks, was regarded as a distinct metal. Copper, especially as the tin alloy, bronze, has been in use from the Neolithic Age, but the current classification putting the Bronze Age before the Iron Age is, according to Dr. C. H. Desch, the metallurgist, not universally true. It depended on which of the two metals existed locally in the form of easily smelted ores, *i.e.*, oxides or carbonates, not sulphides. Iron has been in use in Egypt 5,000 years and probably, also, in some parts of the East. The Delhi pillar, a column of wrought iron, 16 in. in diameter and 24 ft. in length, dating from A.D. 400, if not one of the Seven Wonders of the World, is certainly an Eighth, as to forge such a pillar to-day would be a difficult task even where they forge modern weapons of war.

The Romans used lead extensively for water-pipes and were familiar with the art of soldering with the lead-tin alloy. But they do not seem to have distinguished between the latter two metals, and regarded the mixture as different forms of lead. Antimony, both as metal and as the sulphide, stibnite, has been known from early times and employed in various ways, the latter as a cosmetic,* and a Chaldean vase has been found to have been made of pure antimony. Glass was discovered in ancient Egypt, through the use of soda as a flux in smelting metallic ores with sand. Pottery was practised there, and the art of colouring and enamelling it with metallic oxides, such as those of copper and tin, which were used also to make artificial gems. But porcelain in ancient times was only known in China, where also there existed an alchemical period contemporaneous with the Alexandrian and possibly an offshoot of it.

The manufacture of paints, soap, sugar, starch and turpentine, and the use of fermentation in making beer, wine, vinegar and bread, the burning and slaking of lime for mortar, and many other chemical processes were all well known. Mercury, prepared from the sulphide, cinnabar, by distillation with iron, was known in the Third Century B.C., and used not only as an amalgam with gold for gilding, but also to recover that metal from out-worn gilded fabrics. The alembic, for distillation, was perfected by the Alexandrian chemists, but its use in producing spirituous liquors seems to belong to our era. It was extensively employed by the Arabian alchemists for making alcohol for pharmaceutical preparations.

For not far short of a thousand years, straddling the birth of the Christian era, Alexandria was a world centre of learning probably never before or since even approached. But, by the Fifth Century A.D., it was in decline, through the internecine religious quarrels of Jews, Christians and Pagans, in which Hypathia, the prototype of our Mme. Curie, was murdered (A.D. 415), and two centuries later it was overrun by the Saracens. In this overthrow, the fanatical followers of Mahomet burnt its famous Serapeum and its priceless library, the latter serving, according to widespread if unsubstantiated tradition, as fuel for the public baths of Alexandria for six months. In this way anything left by Diocletian of the origin of alchemy was finally lost to the world.

In surprisingly short time, however, the conquerors, from fanatical barbarians, became the patrons and preservers of learning and culture, so carrying on the civilisations they displaced, after the fall of those of Egypt, Greece and Rome. By the Tenth Century they had established a tri-partite empire with capitals in Cordova, Cairo and Baghdad. The universities they founded, especially in Spain, attracted students from all parts of Europe, who carried back to their own countries the knowledge and training they had there acquired. There, as also in the Byzantium Empire in the East, where Egyptian alchemy had also found a sanctuary, chemistry, now more closely associated with medicine, was fostered and extended, so that by the end of the Thirteenth Century alchemy had reached its zenith throughout Europe.

Best known of the Arabian alchemists is Geber, a name which modern research has found to comprise two people, teacher and pupil, who lived in the second half of the Eighth Century. The

* *Vide The Book of Enoch*, R. H. Charles. Clarendon Press, Oxford, 1912.

* *Vide* II Kings, IX, 30 and Ezekiel, XXIII, 40, where "paint" is literally "antimony."

Arabian alchemists discovered the mineral acids, hydrochloric, nitric and sulphuric, to give them their modern names—which were totally unknown to the ancients, and they recognised solubility in water as a common property of salts, the knowledge of which they greatly extended. But the subject remained the original strange medley of chemistry, materia medica, magic, superstition, and quackery. Apart from certain incipient ideas, mentioned later, as to the nature of elements, the theoretical outlook on Nature was as completely false as before. However, the growing preoccupation with pharmacy, apothecaries' shops from Spain gradually spreading to Italy and Germany in the Eleventh Century, was undoubtedly a purifying influence, paving the way for modern chemistry.

Greek Atomic Theory and its Perversion.

Knowing as we now do that any genuine transmutation of one element into another was immeasurably beyond the recorded resources of the ancients, it is a strange paradox that the Greeks were the originators of the Atomic Theory. Moreover, that theory is, in its general features, almost entirely the one held to-day, and that is not exactly the Daltonian theory that dominated the Nineteenth Century. The Greeks probably acquired their knowledge of mathematics, astronomy and geometry, in the first place, from Egypt, Chaldea and India, and elevated these subjects into true sciences, pursued objectively as ends in themselves, rather than for their practical usefulness. Yet they failed to do this for Egyptian alchemy and, on the contrary, elevated the false, if not wittingly fraudulent, doctrines of the hierarchy concerning the transmutation of base-metals into gold and silver almost into theoretical axioms or truisms, and thereby condemned chemistry, both theory and practice, to a wild-goose chase after a chimera for two thousand years.

It appears to the writer, without as yet having had the opportunity to study the original sources of information, that the Greek Atomic Theory was in origin probably of the nature of a rejection of, and alternative to, the prevalent Oriental speculations concerning the ultimate constitution of matter. It seems, rather, to have been the first-fruits of the application to the problem of the same approach to external Nature as makes Greek mathematics, especially geometry, a landmark in the progress of civilisation. The seed thus sown failed to propagate itself, not because it fell on stony soil, but because it was choked with weeds. Those who professed themselves the followers and disciples of the original Greek atomists in fact inverted and perverted their theory. The latter, naturally, by present-day standards was purely speculative and general, but it is curiously accurate speculation. Let us consider its main tenets.

The theory is usually ascribed to Democritus (470-361 B.C.), none of whose works has survived, but is stated by the historians to have been originated by his teacher, Leucippus, who rejected the doctrine of the so-called Aristotelean elements (earth, air, fire, water), as the ultimate constituents of matter. Instead, he regarded matter as composed of separate particles in empty space, or "atoms," too small to be individually perceptible. Most of what is known about it is derived from the Latin didactic poem of Lucretius (95-55 B.C.), *De Rerum Natura* (Concerning the Nature of Things). It is to be noted, in the first place, that these "atoms" were supposed to be occupying the empty space by their being in perpetual motion, which the early atoms of Newton, Lavoisier and Dalton were not, and that they acted on one another by impact and pressure, not by the "loves" and "hates" (attractions and repulsions) of the Oriental sages. Secondly, the changes of matter were due to the union and separation of the atoms and to their exchanging partners. Lastly, the different properties of matter were attributed to the different shapes and sizes of the atoms, not to their different weights as for the Daltonian atoms.

At least this first recorded atomic theory made it possible to define the "atom" exactly, as the smallest possible quantity representative of any single homogeneous kind of matter. Chemistry, as the most intimate inquiry into matter, as necessarily implies some form of atomism as an intimate study of wheat implies a study of the single grain rather than the sack-full. By "representative" is to be understood exhibiting certain properties, with the implication that further subdivision will cause the disappearance of those properties and the appearance of new ones.

Implicit also in this theory, as it is in the one held to-day, is the feature regarded as most characteristic of early Ionian philosophy, the belief in a primordial entity, out of which everything is, in the last analysis, constituted. For it would be redundant to ascribe the properties to the shape and sizes of the atoms, if the stuff out of which the atoms were made was different for different atoms. The stuff is, by implication, material, or, to use the expression coined by Sir W. Crookes in the last century, a protyle. To

Fig. 3. Robert Boyle (1626-94).

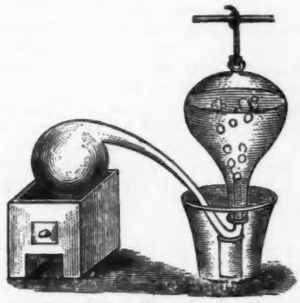


Fig. 4. The First Pneumatic Trough of Stephen Hales.

the first known Greek philosopher, Thales (640–548 B.C.), water was the protyle, but others of the Sixth Century ascribed the role to air or to fire, while to the followers of Pythagoras (570–500 B.C.), it was number, in the sense of harmony, order and rhythm, the first downward step into the inferno of unreality.

By a strange irony, it was the pupil of Democritus, Protagoras (480–411 B.C.) who first sent this interesting anticipation of modern views definitely off the rails. He dropped the atom like a hot potato and started the breach between natural and human philosophy, still unhealed, and to which ultimately has to be traced the disasters which accompany each step forward science takes on the road to the control of Nature. For not only did he drop the atom, but the material world also. He converted Greek Science into Greek Nescience, averring it was not possible to know about things as they "really" are, but only what they appear to our sense impressions to be. He is the originator of the maxim "Man is the measure of all things," later to pass through a variety of shades of meaning, all of them elevating man to the central position in the universe. However applicable it may be to the permissible application of science to human affairs, the one obvious field to which it seems not to have been applied, it is pernicious sophistry applied either to external Nature or to our knowledge of it, and to-day sounds like the presumptuous illusion of a monomaniac.

Greek nescience, this purely subjective and defeatist approach to the external world, was, in succession, avidly seized upon and developed by the better known triumvirate of the Fifth and Fourth Centuries B.C., Socrates, Plato and Aristotle. The first, after some study of natural phenomena, formed the view that as any real knowledge was impossible, its study was unprofitable and useless. He finally came to regard the whole universe, animate and inanimate, as expressly designed for the benefit of man, a point of view that seems still to actuate most people to-day. Plato grandiloquently extended the ruling Greek conception of one primordial entity underlying the material universe to that of the mind also, the whole expressing a single plan, but had no real interest in or knowledge of external Nature. It was his successor and pupil, Aristotle, who laboured to apply the nescience of his predecessors to the world of things, and whose authority over the whole world of learning up to the Sixteenth Century was as absolute as it is now incomprehensible, to whom we are most probably indebted for the universal credence accorded to the cult of the alchemical doctrines of transmutation.

Whatever meaning may before have been assigned to the four "elements" of which everything was supposed to be constituted, to Aristotle they were in no sense either material or constituents, but, rather, qualities or properties. They were, in fact, the four possible combinations of the two qualities hot-ness and wet-ness, and their opposites cold-ness and dry-ness, taken two at a time. Fire was dry-hot; air (or steam), moist-hot; earth, dry-cold; water, moist-cold. To these he added a fifth, or quintessence, of an ethereal nature permeating everywhere and everything. But the same occur in the writings of Buddha, with a sixth, consciousness. Since things can only be known to us by the impression they make on our senses, the problem of the ultimate nature of matter dropped out of the inquiry. Matter was regarded merely as the vehicle, or medium, for the manifestation of properties, and the "elements" became the smallest number of distinct qualities out of which the properties of matter could be made up. Since properties are so easily changeable, there was nothing at all irrational in supposing that the properties of lead might be changed to those of gold. Among the philosophers of the time, if not among the illiterate craftsmen and technicians they so despised for being actually engaged in transforming raw materials into useful products, the most superficial and impressionistic notions throve.

It was thought that the undesirable qualities could be replaced by those desired one at a time. Hence arose the term "coloration" of the metals as indicating a step in their transmutation. Heating copper and calamine stone (zinc carbonate) gives brass, the first step to transmuting the copper into gold. Roger Bacon (1214–94) after referring to the qualities of gold, its colour, high density, malleability and so on, said "those who know the formulæ and practices necessary to produce these qualities at will and reunite them in any substance can change it into gold." The modern mind would at once ask why then the intermediate steps between lead and gold are not found in Nature as well as the two elements themselves.

The Arabian alchemists got one step nearer to reality in their substitution, for the four Aristotelean elements, of three, which they termed mercury, sulphur and salt, as conferring, respectively, metallic properties, alteration by fire and solubility in water. But though they seemed to regard these elements more in the modern sense as material constituents, they were not the actual substances bearing these names, but idealised forms of them, each contributing the quality predominatingly shown by the actual substances.

As alchemy neared its close as an openly studied and reputable subject its doctrines became ever more and more fantastic. There are numerous circumstantial accounts of actual transmutations being performed by scientific people of high repute and unquestioned integrity, but all the articles examined which are reputed to have been made of

artificial gold are imitations. There can be little doubt that those deceived were the victims of the kind of ingenuity that now goes to salt gold-mines. As regards the Elixir of Life aspect, in the Middle Ages the longevity of the Biblical patriarchs was ascribed to their knowledge of alchemy.

Yet, as the writer pointed out forty years ago,* and still regards as curious, it now needs only the slightest effort of imagination to reconcile the apparently meaningless jumble of ideas connected with the philosopher's stone. For transmutation, by the release of an inexhaustible supply of energy, without which all life dies, would be a veritable Elixir of Life. Many other ancient legends, if taken literally rather than mystically, seem to hint that humanity is treading a road it has trodden before, and that these myths may derive from a former epoch of which all other trace has been lost. Before the dawn of recorded history, we find in ancient Egypt a highly advanced civilisation preserving as State secrets by means of the hierarchy, a considerable command of practical science, even if their reputed practice of transmutation must now be regarded as a pretence. If the disasters that threaten do overtake the scientific civilisation, it is not wholly unreasonable to predict a state of future things somewhat akin to that existing in ancient Egypt in the past. The fundamental knowledge so recently and secretly acquired might easily be lost in the upheaval, or only live on in the form of esoteric and anthropomorphic legend. But something of the practical side of science divorced from its original philosophical basis might survive. Already the first fateful steps of making science a State secret under a hierarchy, ultimately no doubt of the appropriate tinge of blood, seem to be inescapable, if they have not already been taken.

The Rise of the Experimental Sciences.

As already mentioned, Robert Boyle was the first, as he put it, "to consider the art not as a physician or an alchemist, but as a philosopher." In his famous work, *The Sceptical Chymist*, he clearly defined the chemical elements in the sense now understood as the undecomposable constituents of matter. He foresaw correctly a great increase in their number, that some then thought to be elements might ultimately be proved to be compounds, and he sagely remarked that it was necessary to know them as individuals before attempting generalisations about them. He was the first to distinguish clearly between chemical compounds and simple mixtures, and to regard the complete change of properties that occurs on chemical combination, as the test of the compound, since with simple mixtures no such changes occur. Boyle is also well known for the law that bears his name, and also that of Mariotte, connecting the volume of gases with their pressure, which, with a similar law for the effect of temperature, discovered later by Gay Lussac, give us what are now called the Gas Laws. In modern form, the two combined are simply $PV = RT$, where P is the pressure, V the volume, T the absolute temperature (Centigrade degrees plus 273), and R is a constant. Robert Boyle's portrait, reproduced from *A Popular History of Science*, by Robert Routledge, is given in Fig. 3, on page 315.

But the period of rather more than a century, which covers the work of Boyle to that of Lavoisier (1743-94), who perished on the scaffold in the reign of terror of the French Revolution, is one of the most confused and misinterpreted in the history of science. It is usually referred to as the Phlogistic Period, from the theory of combustion which Lavoisier finally overthrew. But Boyle was not a phlogistonist, and the Phlogiston Theory, though the direct successor of alchemy, was a later very interesting, though much maligned, parallel growth.

The ancients naturally divided the universe into a tangible, ponderable and visible, or material world, and an intangible, imponderable and invisible spiritual world. But gases were betwixt and between, and, as for energy, it definitely was put in the wrong one, for the early deities, as Thor and Vulcan, if not Jove himself, were mere personifications of physical energy.

Chemistry, as a science, began as what has been termed pneumatic chemistry, that is, with the recognition of gases as distinct substances, rather than "different sorts of air," and, also, with the first elucidation of the nature of salts as compounds of acids and bases, with which we are less directly concerned.* This was over a century before the triumph of the Lavoisierian doctrine that combustion, including respiration and the calcination of metals, consists in the union of the burning substance with the oxygen of the air, and not in the decomposition of the substance into a principle of combustibility, called phlogiston, and the products of combustion.

As regards gases, it was started in the century before Boyle by the Dutch alchemist, van Helmont (1577-1644), to whom we owe the word "gas" (from the German *geist*, meaning spirit or ghost). It was the latter's work on the loss of weight when charcoal is burnt, and his recognition that the carbon dioxide formed is the same gas as that produced by fermentation, by the action of acids on shells, and which lurks in caves and mines, which gave the first indication that gases have weight. We find also in van Helmont's writings, mixed up with the alchemical idea of elements, the first germs of the present view, that the elements continue to exist as such in their compounds, much as salt does in salt-water. Boyle knew that there is a gain in weight when metals are converted to their calces (oxides) and that during respiration and combustion a part of the air disappears, leaving behind a residue unable to support combustion or life.

Mayow (1645-79), in what has justly been termed the most remarkable series of experiments in the Seventeenth Century, on the nature of combustion, showed that nitre (saltpetre) contained a gas supporting combustion, that this gas is "fixed" by antimony which is thereby increased in weight, that the part of the air used up in combustion changes dark-red venous blood to bright-red arterial blood and he ascribed animal heat to its absorption. But for his early death at 35, it is certain he would have arrived at the conclusions reached by Lavoisier at the end of the next century.

In the Seventeenth Century it had been suggested that one of the "elements" of matter caused combustibility, but this was rejected by van Helmont on the ground that fire could not be a material substance. But the view was revived in more definite form in 1669, by the German alchemist Becher, the fire-element, termed *terra pinguis*, being regarded as escaping during combustion. At the beginning of the Eighteenth Century, Stahl (1660-1734), renamed it "phlogiston," and, more important, extended the range of the theory by showing that in many cases burnt substances are "un-burnt," so to speak, by heating with inflammable and combustible substances. Thus the metal calces (oxides) heated with carbonaceous material are "revived" as metals, and, in the same way, sulphur is regenerated from sulphuric acid and sulphates.

No century has produced a more brilliant galaxy of chemists than those who believed in this phlogiston theory of combustion. It included Black, Priestley, Cavendish, Scheele, Marggraff and Bergman, all of whom, except the first, died in that faith, many after the Lavoisierian theory of oxidation had been firmly established by the experimental discoveries and evidence that, ironically enough, they themselves mainly had supplied. It was to their work that we owe—after the method invented by Stephen Hales (1677-1761), of collecting gases by the pneumatic trough (see Fig. 4, page 315), which was unknown to van Helmont, had become general—the recognition, as separate gases, of carbon dioxide, oxygen, chlorine, marsh-gas or methane, hydrogen, and, by collection over mercury, first used by Priestley, of the soluble gases, ammonia, hydrogen chloride, sulphur dioxide and silicon tetrafluoride. Not only was their chemical character and solubility regularly used to distinguish them, but also their density, in which field the work of Cavendish (1731-1810) was outstanding. Hitherto, they have been held up to every school-child as an awful example of pre-conceived dogmas and of neglecting to pay attention to quantitative, rather than qualitative, evidence!

But the historians of chemistry, and also chemists themselves, have misjudged, as well as mis-named, this first era of scientific chemistry, mainly on two grounds. To Stahl and his predecessors, the originators of the theory, phlogiston was an element in the Aristotelean sense, not in that given to the term by Boyle. It was the later followers of Stahl, under the growing influence of Boyle's views, of which Stahl himself was a strong advocate, who came to regard phlogiston as a constituent of matter, rather than the principle conferring inflammability and combustibility. As well known, it was the mistaken identification by Kirwan of hydrogen, after Cavendish discovered that gas, with phlogiston, which led to the conclusive victory of the oxidation theory. It was Cavendish, not Lavoisier, who first proved conclusively that water was not an element, but a compound of oxygen with his newly discovered hydrogen.

Secondly, and less excusably, it seems to have been quite wrongly assumed that the law of the conservation of mass had already been established, whereas it was this very controversy between the phlogistonists and the anti-phlogistonists, which led to that law becoming established. Also, though it is no doubt very important for chemists to know that combustion is the result of substances uniting with oxygen, what the untutored savage and, no less, other people are interested in, is the production of light and heat during combustion, and that, not the gain of mass, is what phlogiston—rechristened, by the way, "caloric" by the Lavoisierians of the next century—was originally invented to account for. As Crum Browne, Professor at Edinburgh University, at the close of last century, put it in a nut-shell, replace phlogiston by energy and the writings of the phlogistonists, from alchemical gibberish, become ordinary modern common sense. Lavoisier established the conservation of mass during combustion, but that did not at all affect the phlogiston theory in its original form. He established that what he termed "fire-material" had no weight.

The era is in fact best regarded as having been the battleground between two ideas competing for birth, the conservation of energy and the conservation of mass. Curiously, it was the former and more elusive that caused the first throes, though it was the latter and more robust that first emerged. Now, as will be told later, the twin laws of conservation have been fused by Einstein into one, and though it may not be true to say that energy and mass are identical, they certainly appear to be mutually convertible. Stahl's contribution to the theory, that the property of combustibility was transferable, and could be restored by the treatment of the products of combustion with fresh combustible material, was a clear enough, if very partial and imperfect, anticipation of the law of conservation of energy, which did not achieve recognition till the middle of the Nineteenth Century.

In sticking to their guns, in spite of the apparently conclusive evidence of the balance in favour of the rival view, the phlogistonists were the first to apprehend a totally new category in the material world, possessing neither tangibility, visibility nor weight (in so far as that can even yet be measured directly), yet like matter incapable of being created or destroyed. It is not too much to say that modern thought, outside science, is not yet abreast of that development, even as understood at the opening of this century, and, inside science, the implications still seem to have been insufficiently appreciated.

As later historians have recognised,* Lavoisier was painfully mean in regard to the splendid experimental work of his contemporaries, to whom he was opposed in theory, if not indeed to all discoveries except his own. Frequently he made no acknowledgement of the pioneering work of others, even when they had communicated it to him personally before publication, and it directly anticipated or influenced his own conclusions. Or he treated it coldly and depreciatingly, whilst meticulously examining the most trivial objections that could be trumped up to discredit it. So that a blot has

* *The Interpretation of Radium*, chapter XI, F. Soddy. Published by John Murray, London, 1909.

* Compare *The Origins and Growth of Chemical Science*, J. E. Marsh. John Murray, 1929.

* Compare E. von Meyer, *A History of Chemistry*, trans. by G. M'Gowan. Macmillan & Co., 1891, page 156.

fallen on the lustre with which his fame has been surrounded by the idealised versions of history due to his admiring compatriots.

On the other hand, perhaps his most important contribution to science, or at least the most important result of it, has, because of other historical perversions, scarcely received recognition at all. For it was the quantitative method of reasoning which he introduced and the conservation of mass which he established, that made it only a matter of years before the existing Atomic Theory, in which the atom is characterised by its weight, as well as by its chemical nature, became unavoidable. The reason that previously the atomic theory had hardly entered the arena of scientific chemistry, and after recognition was for so long suspect, may be traced to the scepticism concerning premature generalisations expressed by Boyle, and to the mistaken association of Greek atomism with alchemical doctrine.

From this point of view, since Lavoisier was primarily and by preference a physicist, it is rather significant that he did not arrive at it himself. But, again, that may have been just because he was not primarily interested in chemical changes. He made no independent discoveries in chemistry. The theory implied by his name for oxygen, which means "acid-former," though it considerably advanced chemistry for a time, was ill-starred, as very soon that role had to be accorded to Cavendish's element hydrogen. Later, with the rise of the Arrhenius Theory of Electrolytic Dissociation, acidity was identified with "hydrion," the positively charged hydrogen ion, which physicists in the present century thought necessary to rename the proton, on account of the fundamental role they ascribed to it in atomic structure, though in acids it is much the same as any other ion in behaving as an ordinary molecule. It is confusing to have two names for the same thing, and, even more so, for the same thing to have such completely differing roles. This initial objection to the name "proton" has, as it happens, proved itself justified, for, nowadays, it is the neutron that is what the name "proton" was intended to mean, and the proton is a compound of the neutron and positron, or positive electron.

No better illustration of the power of the quantitative method of reasoning can be given than that in which Lavoisier in one of his earliest researches resolved an ancient chemical misconception by purely physical methods. The ancients believed that water is transformed into air (steam) and earth (residue of dissolved matter) by heat, and this easy apparent transformation of what they regarded as the fundamental "elements" of matter may have misled them to believe in the possibility of transmutation. Lavoisier found that if water is boiled for a long time in a sealed glass vessel there is no change of weight, and that the weight of the earth left on evaporating the water equals the loss of weight of the glass vessel in the process. By exactly the same method, he later established that phlogiston, or, as he termed it, fire-material, had no weight. For if easily fusible metals are calcined in a sealed glass vessel, containing air originally, there is no change of weight until the vessel is opened and air equal in volume to the oxygen absorbed by the metal, rushes in. By contrast, as an example of the qualitative method of reasoning, may be cited Scheele's way of resolving the above ancient misconception, by the chemical examination of the residue left on evaporation of the water and the proof of the identity of its constituents with those of glass.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The South Midland Centre of the Institution of Electrical Engineers has formed an Installation and Transmission Group for the 1947-48 session. Further information can be obtained from the honorary secretary of the Centre, Mr. H. Hooper, 53, Wake Green-road, Moseley, Birmingham, 13.

ELECTRICITY CUTS IN FRANCE.—The French Ministry of Industry and Commerce have announced that as from Wednesday, September 24, industries throughout the country are to receive electric power on only four days a week. Domestic consumers now have their current cut off on two days a week, from 7 a.m. until 8 p.m., except at meal times. It is stated these restrictions are due to the shortage of coal.

LITERATURE.

Cellulose Plastics. By D. N. BUTTREY, M.Sc., A.R.I.C. [Price 7*s.* 6*d.* net.]. *The Metallisation of Plastics.* By J. R. I. HEPBURN, D.Sc., F.R.I.C., F.I.M. [Price 6*s.* net.] *Fabric Reinforced Plastics.* By W. J. BROWN, M.I.E.E. [Price 7*s.* 6*d.* net.] Cleaver-Hume Press, Limited, 42a, South Audley-street, London, W.1.

THE books under review are three of a new series of monographs, each intended to survey a limited area of the plastics field in a concise, yet comprehensive, fashion. The main problems facing the authors, consequently, have been to decide what to omit, and then to combine the selected essentials into a readable account independent of the many scattered sources of original matter. These are tasks calling for specialised knowledge of certain branches of plastics technology at once so intimate and so up to date that the information presented shall be not only precise as regards what is already well established in theory and practice, but based on sound judgments of what are going to be the most important developments in the foreseeable future. It is worth noting, therefore, that all three authors are adequately qualified in these respects by their standing in the plastics industry and their extensive knowledge of its technical literature.

Notwithstanding their common characteristics of the sort indicated, the books differ markedly in method of treatment of their subjects and appeal to correspondingly different groups of readers. Mr. Buttrey's approach to cellulose plastics, for example, is predominantly that of the chemist, presenting to technicians who have a good background of chemical knowledge but no special acquaintance with cellulose and its derivatives, a general account of the raw materials of commercial cellulose, of the manufacture of cellulose plastics, and of the factors underlying their outstanding properties. References to methods of processing, producing and testing are deliberately typical, the text being concerned rather with the underlying theory and the general principles controlling the properties of cellulose nitrate, cellulose organic esters and the more recently developed cellulose ethers.

Dr. Hepburn's expert knowledge and original investigation of the deposition of metallic films enable him to deal authoritatively with the technical details involved in coating plastic materials by electrolytic, bronzing, cathode-sputtering, and vacuum-evaporation processes; mechanical attachments of metal by inserts or adhesions are outside the scope of his survey. The application of previously-established methods of deposition on non-metallic substances presents many new problems which Dr. Hepburn discusses in relation to the theoretical aspects of adhesion, the practical factors contributing to successful results, and the economics of alternative methods and materials. Since the commercial development of plastics metallisation is as yet in the early stages, Dr. Hepburn's book is necessarily tentative in some respects, but, for that reason, may be the more attractive to plastics technologists and scientists generally, to whom the opportunity is afforded to learn easily almost all that can be disclosed at present about a subject which has interesting possibilities of future development.

On account of its wider scope, Mr. Brown's subject lends itself less readily to comprehensive treatment, and, therefore, the fact that a great deal of ground is adequately covered is the more creditable. Mr. Brown emphasises the fact that the mechanical properties of fabric-reinforced plastics differ markedly from those of either of the materials combined, and the most original portions of his work are concerned with the influence of the substances used and the methods of processing them upon the ultimate characteristics. He presents some interesting, if speculative, views on aspects of fabric reinforcement that are at present obscure, incidentally revealing an impressive knowledge of textiles and plastics which elsewhere enables him to deal critically with the collected information about the materials, manufacturing operations, physical properties, testing and industrial applications of fabric-reinforced plastics, which comprises the main body of his book.

The scientific and scholarly style in which Mr. Brown assembles his material and presents his considered opinions is typical also of the other two monographs, both of which are also first-rate contributions to plastics literature. Each book is documented, illustrated, and complete in itself, while being commendably free from unnecessary elementary matter. Each author gives the impression of being an authority on his subject, whose judgment on controversial points can be accepted with confidence. Such qualities appeal strongly to technical readers outside the plastics industry, and engineers in particular, whose work may touch upon the fields covered, will find these books useful for study and reference.

Six-Place Tables: with explanatory notes by PROFESSOR EDWARD S. ALLEN. Seventh edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York, 18, U.S.A. [Price 2·50 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 12*s.* 6*d.*]

THIS set of six-figure mathematical tables, originally published in 1922, is particularly welcome, as six-place tables are rare in comparison with those of four, five or seven figures; in fact, the only other well-known six-figure tables that we can recall are those of Bremiker. A short introduction outlines the theory of logarithms, describes the tables themselves, explains how linear interpolation is carried out and provides a set of exercises, without supplying answers to them. The sign of equality appearing in three lines on page xix should be replaced by a minus sign.

The material tabulated is as follows. Table I gives squares, cubes, square roots and cube roots, reciprocals of the integers from 1 to 1,000, together with the circumferences and areas of circles having these numbers as diameters. Table II gives fifth powers and fifth roots, and Table III, circumferences and areas of circles with diameters advancing by eighths up to 100, followed by decimal equivalents of fractions. Table IV is one of logarithms to the base 10 with four-figure argument and proportional parts. Table V gives the common logarithms of the trigonometrical functions, the angles being given in degrees and minutes, together with differences for 1 second and the auxiliary functions S, T and C required for operation within the "awkward" interval between 0 deg. and 2 deg. The printing of negative characteristics is avoided by adding 10 to the values listed. Table VI provides values of the six principal trigonometrical functions for argument in degrees and minutes, but without tabular differences. Data for the conversion from radians to degrees and vice versa are supplied in Table VII and the next table is a four-figure one giving values of sin, cos, tan, cot, log sin, log cos and log tan for angles 0 (0·01) 3·2 in radians.

Table IX gives the common logarithms of factorials for each integer from 1 to 100, with a statement of Stirling's formula, applicable for all ordinary computation purposes to numbers over 100. Table X is one of natural logarithms covering the range 0 (0·001) 9·999. Table XI gives e^x, e^{-x}, $\sinh x$, $\cosh x$ and $\tanh x$ for values of x 0 (0·001) 1 (0·002) 2 (0·005) 3 (0·01) 4 (0·05) 5 (0·1) 6 and 0 $(0{\cdot}1\pi)\pi$. It is followed by short tables of the gamma function and of the probability integral. Table XII contains a list of trigonometrical formulæ for the solution of plane and spherical triangles. Table XIII consists of a useful collection of indefinite and a few definite integrals. A table of the complete elliptic integrals K and E is followed by a note on partial fractions, while the final table comprises values of certain mathematical constants. It will be apparent that the selection included in this volume of 250 pages comprises practically all the tables of the elementary functions currently needed in the applications of mathematics to engineering. Despite its small and handy format, the standard of legibility is high and the location of the various tables is facilitated by the provision of a marginal index.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—A new edition of the list of members of the North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1, corrected to July 31, 1947, is now available. Members of the Institution can obtain copies on application to the secretary.

THE EFFECT OF ATOMIC ENERGY ON SCIENTIFIC AND TECHNICAL PUBLICATIONS.*

By Professor R. E. Peierls, C.B.E., F.R.S.

(*Concluded from page* 305.)

The rules themselves do not release the data on any particular problem. If I want to use, in a discussion, material contained in a report that I have written for the project, I may also happen to be a responsible reviewer and I may know that this report comes into a category which can be declassified under the present rules. Yet it would be illegal for me to disclose it until I had requested declassification of my report, which would then be sent to some other reviewer for an opinion. The opinions of the reviewers have, in themselves, no legal force; they act only as advisers and the final responsibility for declassification has to be taken by the officials of the appropriate Ministry, who will act on the authority of the Minister, taking into account the recommendation of the reviewer.

In these cases, the question of secrecy is not the only obstacle to releasing information. The officials have to bear in mind that the information may represent an invention in the sense of patent law, which may well be of considerable commercial value if it is applicable to engineering problems that go beyond the field of atomic energy. All such inventions made by scientists working for the project are automatically Government property. Due regard must be paid to the need for protecting the rights to such an invention, where necessary, by a patent application before they are made public, since otherwise legal complications may arise. I believe, however, that this point may at the worst only delay declassification, not prevent it.

It is, of course, a part of the rules for declassification that, if a report contains only information which has already been published elsewhere or has been declassified, it should be released. In this way, reviewers can do their work effectively only if they know the contents of all declassified papers and all published articles, etc., at least in their own special field. With the rapidly increasing amount of such literature, this represents a most formidable job and it is unavoidable that occasionally a reviewer should recommend against declassification of a piece of information, although this had already been mentioned, say, in a Press statement of some official or in some popular article, which the reviewer had not seen or does not remember. To remedy this, it is clearly necessary to catalogue all published and declassified information in the field of atomic energy in a way which would make it possible, without much labour, to turn up all that has been disclosed on some particular point. As far as I know, such a catalogue does not exist as yet; it is hoped that its compilation will be undertaken soon and this would help to speed up declassification procedure and to improve its consistency.

In any case, the description which I have given of the rules makes it clear that they cannot work without a good deal of flexibility and without gradually building up a case law. From time to time, situations arise which were not foreseen when the rules were drafted and for which no provision is made. In this case, a new rule is necessary, or it may be necessary to amend the existing rules. It is important to remember that this process of declassification goes on in three countries and that its purpose would be nullified if the policies of reviewers in different countries were different. There is clearly no sense in our keeping secret a piece of information which is being published in the United States, or vice versa. Hence, any amendment for extension of the rules needs international consultation and this further duplicates the machinery.

The story does not end when a report has been declassified. It is now the practice of the Ministry of Supply in this country, of the Atomic Energy Commission in the United States, and of the corresponding department in Canada, to make copies of any declassified report available immediately to all workers on the project and other suitable people, such as research workers in universities or in industry. The Atomic Energy department of the Ministry of Supply, in particular, publishes lists of titles of such reports from time to time, and reasonable requests for the loan of copies are met within the limitation of the number of copies available. Copies are also deposited in the Science Library. In general, such reports are not suitable for immediate publication. They were usually written in a hurry and they usually assume prior knowledge of all previous reports in the same series, of which the earlier ones have meanwhile become obsolete. Usually, it is necessary, therefore, for the original authors to re-edit their work for publication. Anyone who knows the habits of scientific authors and who remembers that many of them have now returned to work in other fields and are anxious to make up for lost time in these more peaceful pursuits, will appreciate that this job will not be done quickly.

How is all this affecting the position about scientific publications in practice? It is certainly true that there remains on the secret list a good deal of information which would help research if it were available. Some of this is so intimately linked with vital data about plants or weapons that, in the present situation, we cannot expect to get it released. I can here speak with first-hand knowledge only on information on nuclear physics in particular, and most of this information is not of a fundamental nature. There are other more specialised techniques that cannot be released and would be helpful, but, broadly speaking, this type of information is usually not vital for fundamental research. There may be more important things in other fields, such as engineering, metallurgy and chemistry, which must remain secret, but which would be of value outside the atomic energy project itself if they could be reclassed.

There is still a wide class of data which comes under the rules of declassification and which will presumably be declassified once the wheels of the machine have made a sufficient number of revolutions. They will, no doubt, be published if they are of general interest, once their authors have made an effort to prepare them for publication. In some cases, the whole field of work dealt with by a particular branch of the project has been, or is being, written up as one systematic report rather than a number of different papers. The most important example of this is the "Technical Series," prepared by several branches of the American Atomic Energy Project. These, too, of course, have to go through the declassification procedure and, as far as I know, none of them has been published yet.

What can be done to speed up declassification and publication? The first point, of course, is to keep reminding those in charge of the importance of scientific discussion and the adverse effect which unnecessary restriction of freedom has, not only on scientific work in general, but on the efficiency of the work in Government laboratories themselves. I believe that this situation is clearly understood by everyone concerned and that all officials connected with declassification are doing their best to help rapid and liberal application of the accepted policy.

While the procedure goes on, one can feel the delays produced, even within the project, by people lacking knowledge to which they would be entitled as members of the project, and which would be essential to their work, but which has not come to their notice since the observation of security rules and the free dissemination of knowledge, even within a closed laboratory, are not compatible. I can see no easy universal remedy to this, other than the complete abolition of scientific secrecy, for which at present, I believe, there is no hope. The situation can be alleviated by pressing for a generous interpretation of declassification policy and by impressing continuously the importance of the problem so as to make sure that sufficient effort is put behind the administration machinery on which classification depends.

I believe that, at present, the practical effects of the secrecy clause of the Atomic Energy Act are completely negligible, although potentially the legal powers contained in the Act are very much more drastic. The reason is, first of all, that, at least in the field of nuclear physics, the exemption Order under the Atomic Energy Act has, in fact, released almost everything that a scientist not directly concerned with atomic energy would ever want to talk about. It might at first sight appear illogical that this Order frees information which would not be declassified under the Official Secrets Act; but this is as it should be. The Atomic Energy Act refers to work done outside the Government project. If some information can, in fact, be found in an independent university laboratory, there is not much point in keeping it secret, since it is only reasonable to assume that anyone seriously contemplating a major atomic energy project would possess resources at least equivalent to those of a university laboratory.

Another reason why the Atomic Energy Act has little effect is that, at the moment, a large proportion of the scientists working on problems of this kind have knowledge of secret material acquired through work during the war. It is conceivable that putting all their war-time experiences aside, they might independently produce some new results which come under the secrecy clause, but in practice this is likely to be influenced by their official knowledge and would, therefore, come under the Official Secrets Act. If any team of university scientists, containing a former member of the project, obtain results of direct importance for atomic energy, the only way to establish that the inside knowledge had not, in fact, been used would probably be to submit the paper for declassification. This would still be the position if there had never been an Atomic Energy Act.

Yet we should not forget that there are in the Atomic Energy Act powers which, applied in a less intelligent way than they are at present, might well prove extremely dangerous to scientific intercourse. If the Minister of Supply, perhaps some different Minister in a different Government in the distant future, were to revoke the present exemption Order without an adequate substitute, a good deal of scientific information might become excluded from publication and discussion. It does not follow that, in reasonable cases, people violating the law would be penalised, but opinions as to what are reasonable situations may differ and the limits can only become clear when, at some time, one goes too far. Even where there are no actual prosecutions, their legal possibility may well hamper scientific freedom. It is conceivable that editors of scientific journals, who would also be breaking the law if they merely reproduced a scientist's indiscretion, could be intimidated by the risk and would insist on submitting all papers in a wide range of fields to a voluntary censorship. This would greatly hamper publication. Fortunately, scientific publishers do not seem easily intimidated; at any rate, in the brief interval between the passage of the Atomic Energy Act and the exemption Order, they happily continued publishing in the normal manner, thereby, no doubt, committing a large number of technical offences. Might the reason for this be that none of them had read the Atomic Energy Act, so that they acted in ignorance of the law?

I belong to the few people who expressed concern at the passage of this clause in the Act, not because of any immediate ill effects, but because of the uncertainty it might create and because its practical advantages were so minute compared to the harm that might be done if it were misapplied. I do not believe there is serious danger of this section being misused, and I am convinced that, if ever an attempt were made to misuse it, pressure of public opinion would be exercised strongly against this. This will work, however, only if scientists and those concerned with scientific publications keep themselves informed about the position, to be ready to make their case if it arises.

* Paper delivered at the Aslib Annual Conference, held in London on September 19-21, 1947. Abridged.

AUTOMATIC CONTROL OF STREET LIGHTING IN AYRSHIRE.

An elaborate system of "Rythmatic" ripple control equipment has recently been installed on the system of the Ayrshire Electricity Board by the Automatic Telephone and Electric Company, Limited, Strowger Works, Liverpool, 7. This system covers 1,100 square miles and serves 70 towns and villages, 12 of which have populations of between 5,000 and 4,000. The "Rythmatic" installation at present enables the street lighting in Largs, Adrossan and Ayr to be switched on from central control equipment at Kilmarnock. Relays, however, are being erected in the street lamps in other burghs and should have been ready for operation by the end of September. Control is also exercised over the water heaters on the system from Kilmarnock to Largs, a distance of 28 miles to the north, and to Ballantrae, 50 miles to the south.

Power for the system is generated at Kilmarnock, the maximum load on the plant being 72,000 kVA, of which 30,000 kVA is exported to the grid. It is transmitted to the area, which is normally divided into two sections, at 3·3 kV, 11 kV, 22 kV and 33 kV. The injected ripple current for control purposes is generated by a motor-alternator, consisting of a squirrel-cage motor, which is coupled to an alternator with an output of 50 kW at a frequency of 485 cycles per second. Current at this frequency is supplied through a line-oscillation transformer, tuning inductors and director capacitor coupling to the two sections of the 11-kV system and thence to the operating relays. These relays operate at voltages between 0·4 volts and 5 volts and discriminate between the signals by means of two types of filter, one of which is mechanical and the other electrical. The mechanical filter consists of a spring-controlled oscillating galvanometer, while the electrical filter comprises a resonant circuit, which accepts the signal frequency and rejects the 240-volt 50-cycle potential. The signal current is then rectified and applied to the galvanometer relay, which swings at a fixed periodicity depending on its springs. As the number of pulses in harmony with the natural periodicity of the relay received increases, the swing of the armature builds up in amplitude to a point where a contact is closed and the circuit of a mechanically-locking switch is completed. This closes in turn, and performs the appropriate switching operation.

The controlling signals are initiated from a desk at Kilmarnock on which a "transmit" push-button and two nine-position rotary switches are mounted. Each of these rotary switches has an "off" position and eight signal positions. To initiate a signal, the rotary switch is moved to the selected position and the "transmit" button depressed so that a signal is transmitted to the appropriate relay. The switching positions of the various relays on the network are indicated by lamps, which are controlled by relays.

UNITED STATES FUELS AND THE COAL-BURNING GAS-TURBINE LOCOMOTIVE.*

By JOHN I. YELLOTT and CHARLES F. KOTTCAMP.

THE gas-turbine locomotive has become a subject of increasing interest since the first Brown-Boveri unit was placed in service on the Swiss Federal Railways in 1941. At the present time, twelve gas-turbine locomotives are being designed in the United States, Great Britain, Switzerland, and France, including two which the Locomotive Development Committee is building to use bituminous coal. It is anticipated that the use of bituminous coal, the cheapest source of energy for most railroads, in a gas-turbine power plant of good efficiency, will result in a very material reduction of locomotive operating costs.

The United States contains unequalled reserves of fuels. The various ranks of bituminous coal and lignite are widely distributed throughout the nation, and only the Pacific coast is without major coal deposits. It is estimated† that the bituminous coal reserves would last for approximately 3,000 years at the present rate of consumption, whereas, at January 1, 1946, the petroleum reserves were equivalent to 12·3 years' consumption, and the natural-gas reserves to 34 years' consumption. New oil discoveries have, in the past, kept pace with consumption. It is becoming increasingly expensive to find new oil, however, and it is likely that the cost of oil will rise more sharply than that of coal in the future. Fortunately, the United States will never exhaust its supply of liquid fuels because any desired liquid hydrocarbon can be made from either natural gas or coal.

As the competition for the available oil becomes more intense the price is certain to rise. The point at which synthetic motor fuels can compete in the market will be reached when gasoline goes only a few cents higher than its present price. It is more difficult to predict when heavier fuels will be synthesised. Obviously, it will be more economical to use coal directly, provided that a coal-burning prime mover can be developed which will have a thermal efficiency approaching that of the Diesel engine. The two coal-burning gas-turbine locomotives which are now being built for the Locomotive Development Committee are intended to achieve this.

Coal is, for most of the American railroads, far cheaper than any other source of energy. At an average price of less than 4.00 dols. a ton, the cost of energy in the form of bituminous coal is about 15 cents per million B.Th.U. Diesel fuel at 7 cents to 8 cents a gallon costs from 52 to 59 cents. per million B.Th.U., or from 3·5 to 4·0 times as much as bituminous coal. Heavy oil at 5 cents a gallon (2.10 dols. a barrel) costs about 32 cents per million B.Th.U.

For the past four years, railroad fuel purchases have cost more than 500,000,000 dols. per annum and have represented approximately 35 per cent. of the total purchases of materials and supplies. Railway coal requirements have represented about 21 per cent. of the total national coal production. Fuel oil of the heavy, residual variety, has been purchased in large quantities by the western roads for many years. The total annual consumption of heavy oil since 1940 has been between four and five billion gallons or, when the consumption is expressed in barrels, about the same numerically as coal consumption in tons. The purchasing of Diesel fuel by Class I railroads has increased tremendously in the past ten years. The consumption in 1946 was approximately 550,000,000 gallons, and this figure will certainly be exceeded in 1947.

The fuel cost for operating any prime mover can be expressed in cents per horse-power hour as

$$\frac{2{,}545 \times 100}{\text{thermal efficiency}} \times \text{fuel cost in cents per B.Th.U.}$$

Thermal efficiency is set within narrow limits by the type and characteristics of the prime mover, a matter which is discussed later in this paper. The price of the fuel, however, is not subject to the control of the railway, and it is obvious that the operating cost per horse-power hour will vary directly with that price. Increases in mechanisation at the mine will reduce the number of man-hours required to produce a ton of coal, and these technical advances should offset to a large extent the anticipated increase in the hourly earnings of the miners. In addition, new types of mining machinery are being developed, which should make possible a marked reduction in the man-hours required to produce a ton of coal. The average quantity of coal burned per 1,000 gross ton-miles of freight service has been reduced from 175 lb. in 1917 to less than 120 lb. in 1946. The equivalent pounds of coal per passenger train-mile have been reduced from slightly more than 19 in 1917 to about 15 in 1946. These figures are not likely to be reduced much in the near future until the coal-burning gas turbine comes into operation.

The demand for gasoline has risen steadily since the war, while consumption of all petroleum products in the first quarter of 1947 exceeded by 300,000 barrels a day the highest war-time requirements. The great increase in the number of domestic oil-burner installations has taxed the ability of the oil industry to supply the distillate fuels which are needed for this type of service. The high-speed railway Diesel engine also requires a distillate oil of about the same quality as is used in the domestic oil burner. The price of this fuel has been increasing rapidly during the past year, and there is every reason to believe that it will continue to increase, as the trend towards domestic oil heat becomes more marked. Shortages in the gas supplies of virtually all the major distribution systems have caused many prospective gas users to turn towards oil instead.

The residual-fuel oil market is no more encouraging than the Diesel oil situation, since the new refining processes are able to turn into gasoline or Diesel oil a much larger fraction of their crude supply than was possible with the older refining methods. There is very little incentive for the oil companies to produce residual oil, since the refined product can be sold at a higher price.

Although the United States will never run out of liquid fuels, since they can now be synthesised, the cost of the synthetic product will exceed the 5 or 6 cents a gallon of Diesel oil on which many economic studies of railway motive power were based. It is to be anticipated that unlimited amounts of energy in the form of bituminous coal will be available at prices ranging from 15 to 25 cents per million B.Th.U. for many years, while it is relatively certain that the price of Diesel oil per million B.Th.U. will approach and even pass 60 to 70 cents within the next few years. Eventually, all our liquid fuel will come from coal, at a cost much greater than that of the original substance itself, because of the additional expense of processing the fuel.

On November 1, 1946, the Class I railroads of the United States owned 37,571 steam locomotives, 3,352 Diesel, and 741 electric locomotives. Approximately 7,000 of the steam locomotives burned heavy oil, while the remainder used coal as their fuel. Almost half the steam locomotives were more than thirty years old, and another 30 per cent. were approaching the quarter-century mark. Only about 2,000 of the steam locomotives were built since 1930.

Of the locomotives on order in 1946, however, 856 were Diesel-electric and only 55 steam. The major builders report that the export business for steam locomotives is still good, but virtually all of the orders being placed by American railroads are for Diesels. A number of lines have expressed their intention of converting completely to Diesels. It is likely that the cost of Diesel fuel will increase to a very marked extent before the useful lives of many of these new locomotives have ended.

In comparing the types of locomotives which will be available for main-line service, the fuel cost per horse-power-hour can be estimated with reasonable accuracy, using the expression given above. The steam locomotive cannot obtain a high thermal efficiency because of the cycle which it uses. Without a condenser, the efficiency cannot be more than 10 per cent., and boiler losses further reduce the efficiency to a maximum of less than 7 per cent.; but because the steam locomotive burns coal which is relatively low in cost, the fuel cost per horse-power hour is still competitive with that for other existing locomotive types. Of the total heat energy available in the coal, 6·7 per cent. is transformed into useful energy, 51·7 per cent. is lost in the exhaust, 31·3 per cent. goes in boiler losses, 5·8 per cent. is radiated from the cylinders, 1·2 per cent. is absorbed by friction, and 3·3 per cent. by the auxiliaries. The Diesel-electric locomotive has the highest thermal efficiency, but it uses relatively expensive fuel, and the cost of the lubricating oil generally exceeds 10 per cent. of the fuel bill. Of the total heat energy available in the fuel oil, 26·4 per cent. is turned into useful work, 33·4 per cent. is lost in the exhaust, 32·7 per cent. is lost through the cooling water, 5·8 per cent. is absorbed by the transmission, and 1·7 per cent. by the auxiliaries. The coal-burning gas-turbine locomotive is expected to have an efficiency at the rails of about 20 per cent., the anticipated losses being 72·3 per cent. in the exhaust, 4·4 per cent. in the transmission, 0·6 per cent. in the lubricating oil, and 2·7 per cent. for the auxiliaries. The thermal efficiency is lower than for the Diesel engine, but the ability of the gas turbine to use low-cost fuel will give it a definite advantage over the Diesel. The fuel costs in cents per horse-power hour are estimated at 0·571 for a modern steam locomotive, 0·532 for a Diesel, 0·398 for an oil-fired gas-turbine in the western States, 0·274 for an oil-fired gas-turbine in the eastern States, and 0·190 for a coal-burning gas-turbine.

A freight locomotive has only the task of starting and pulling the train, and of supplying compressed air with which to operate the brakes. A passenger locomotive has a different function, since it must not only draw the train, but also supply the energy which is needed to heat or cool the cars, and to supply the multitudinous services needed in modern passenger trains. During the winter, almost as much energy leaves a passenger locomotive in the train-heating steam as in the work done by the wheels on the rails. A high-speed passenger train needs from 300 lb. to 400 lb. of steam an hour for each car, to maintain comfortable conditions when the outside air temperature is 0 deg. F. The pressure of the steam must approach 300 lb. per square inch (413 deg. F.) at the locomotive in order to force steam to the last coach of a 17-car train. In addition, lighting, battery-charging, cooking, and other power needs can readily mount up to 500 h.p.

The gas-turbine locomotive offers an excellent opportunity to effect a marked economy in passenger train operation, since it rejects all of its unusable heat in the form of hot air from the exhaust. The use of a waste-heat boiler can reduce to a minimum the amount of fuel which must be burned to supply train-heating steam. It is estimated that the "train thermal efficiency," with 18 coaches at 60 miles an hour on a level track and an outside temperature of 0 deg. F., would be 12 per cent. with a steam locomotive, 38 per cent. with a Diesel-electric locomotive, and 45 per cent. with a coal-fired gas-turbine locomotive provided with a waste-heat boiler. The "train thermal efficiency" may be defined as the amount of useful energy going out of a locomotive divided by the total amount of heat supplied to the locomotive in the form of fuel. A Diesel-electric locomotive is inherently a more efficient power plant than a simple gas turbine, but the gas turbine may well prove to be the more efficient method of providing the energy requirements of a modern passenger train.

A gas-turbine power plant is one in which the working fluid remains in the gaseous state throughout the entire cycle. The open-cycle gas turbine uses heated air as its working fluid, drawing in air continuously from the atmosphere, compressing it in a rotating compressor, and heating it by burning the fuel directly in the air stream. The heated air expands through a turbine, where it does enough work to drive the compressor and to supply useful power. The air is then exhausted to the atmosphere. This "open cycle" is both the simplest and the least efficient arrangement which can be employed. A more efficient arrangement may be achieved in which the compressed air is preheated by receiving heat from the exhaust as it passes through the regenerator to the combustion chamber.

In the closed-cycle arrangement, the fuel does not burn directly in the working gas, but instead, the heat is transmitted through a heat exchanger, while the products of combustion are exhausted to the atmosphere. After the working gas has passed through the turbine, it is cooled to a temperature which can be used efficiently in the compressor. This arrangement has a number of advantages for stationary applications, but it is impractical for locomotive applications because of the size of the equipment and the necessity for large quantities of cooling water.

In a typical open-cycle gas-turbine with a regenerator, for each pound of air passing through the cycle, 88·2 B.Th.U. of work must be done by the compressor, but the same pound of air can provide 140·6 B.Th.U. of work as it expands through the turbine. Thus 52·4 B.Th.U. of net power is available at the generator coupling for useful work; 180 B.Th.U. had to be added to each pound of air by burning fuel in the combustion chamber, so that the cycle efficiency is 52·4 divided by 180, or 29 per cent. When the losses which must be overcome in such a cycle are taken into account, the thermal efficiency at the coupling still exceeds 25 per cent.

(To be continued.)

* Paper entitled "Coal and the Gas Turbine Road Locomotive," presented before the annual meeting of the Association of American Railroads, Operations and Maintenance Department, Mechanical Division, June 23 to 28, 1947, at the Convention Hall, Atlantic City, N.J. Abridged.

† *Mechanical Engineering*, vol. 69, page 221 (1947).

RECONSTRUCTION OF MESSRS. J. H. TUCKER'S WORKS.—Messrs. J. H. Tucker and Company, Limited, King's-road, Tyseley, Birmingham, 11, are formally opening a newly reconstructed office block on Saturday, November 22, the seventh anniversary of the destruction of the works by enemy action. They are anxious to get in touch with all those who have been associated with the company since 1892, so that invitations may be issued.

CORRESPONDENCE COURSE ON LOCKS AND KEYS.—Messrs. Josiah Parkes and Sons, Limited, Union Works, Willenhall, have announced that they are sending out the first lecture of a correspondence course they have prepared, to cover the subject of locks and keys, on Wednesday, October 15. This course will consist of ten lectures covering types, mechanisms, control, manufacture, history and markets, and the fee will be one guinea.

SERVICE PERFORMANCE OF S.S. "SUSSEX TRADER."

In the issue of Engineering for June 20, 1947, on page 521, a note appeared recording the trial trip, on May 16, of the single-screw cargo vessel Sussex Trader, built for the Trader Navigation Company, Limited, London, by Messrs. Sir James Laing and Sons, Limited, Sunderland, and engined by the North-Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne. Since that date the vessel has made a successful maiden voyage, and during the first stage of this voyage, from Antwerp to Liverpool, three trials were carried out to ascertain the behaviour of the engines and boilers under normal conditions of service.

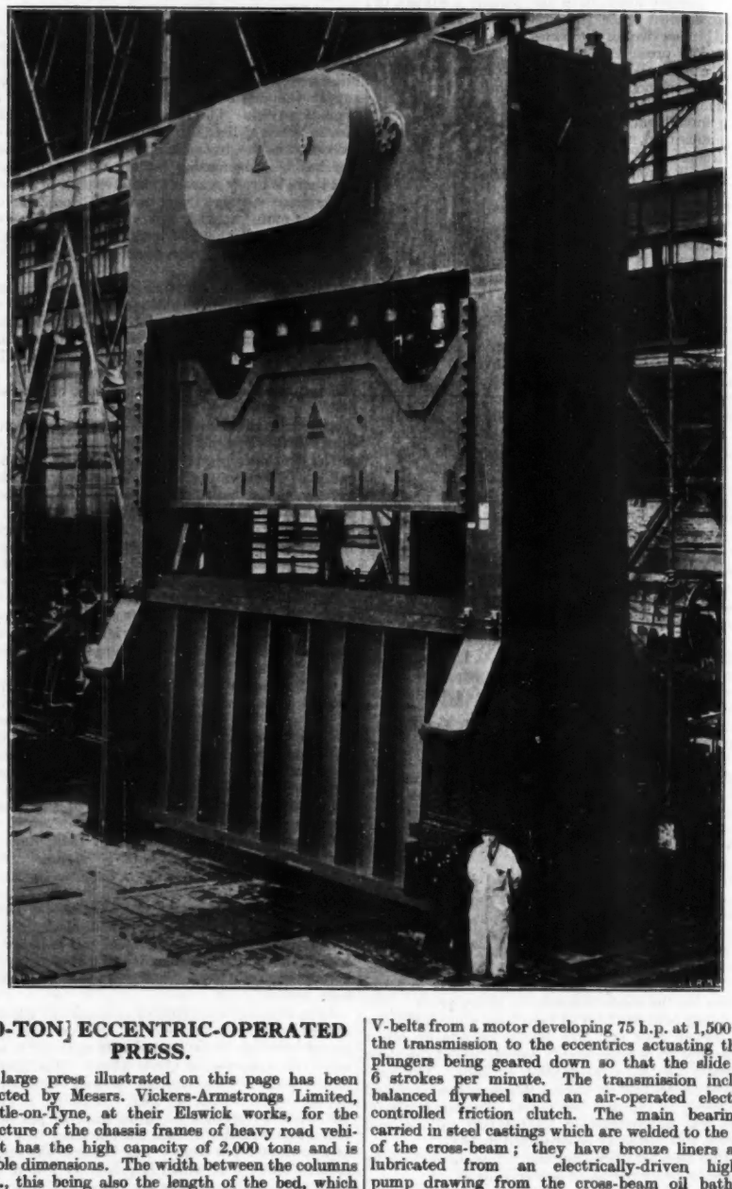
The results of the trials, it is considered, may be of interest to those still concerned with the use of reciprocating steam engines for the propulsion of cargo vessels, as the mechanical efficiency of the engines and the thermal efficiency of the boilers are notably high for their types. Prior to these trials, the vessel had been fitted with calibrated tanks for the measurement of main and auxiliary water consumption and for fuel-oil consumption, a torsionmeter, calibrated pressure gauges, indicators, thermometers, etc., and all other apparatus requisite for testing the boilers, engines and auxiliaries, a specially-designed apparatus being fitted, in addition, for measuring the resistance to steam flow in various parts of the engine. The trials were carried out by a recording staff from the engine-builders' firm, with the co-operation of the ship's staff, and under good weather conditions. The recordings were made when the machinery had been steaming steadily for some hours at the required settings. The displacement on the trials was 5,923 tons at a mean draught of 14 ft. 4 in., the vessel being well down by the stern. The draught at the designed full load of 7,500 tons is 23 ft. 7½ in. The vessel had not been dry-docked for two and a half months prior to the trials.

The main dimensions of the S.S. Sussex Trader are 380 ft. by 54 ft. 5 in. by 34 ft. 6 in. The main engines are of the triple-expansion reheated type, with cylinders 23 in., 38 in., and 65 in. in diameter by 45 in. stroke, and have poppet-valve gear with Stephenson-link motion for the high-pressure and intermediate-pressure, and a balanced double-ported slide valve for the low-pressure cylinders. There are two main boilers, of the single-ended Scotch type, each 16 ft. in external diameter by 12 ft. 6 in. long, having 5,900 sq. ft. of heating surface; and one auxiliary boiler, 12 ft. 6 in. in external diameter by 11 ft. 6 in. long, with a heating surface of 1,750 sq. ft. All three boilers are oil-fired and are designed for a working pressure of 220 lb. per square inch. Superheaters are fitted in the two wing furnaces of each main boiler, and there are air heaters of the three-flow tubular type. Reheating is effected by a tubular heater in which the exhaust steam from the high-pressure cylinder is passed to the intermediate-pressure steam chest over tubes containing the superheated steam on its way from the boiler to the high-pressure cylinder. Feed heating is done in two stages. The first of the three separate trials is the only one that need be referred to here. It was a service-power trial, with the galley and domestic steam in use. The boiler steam pressure was 198·3 lb. per square inch, which gave a pressure of 187·5 lb. per square inch and a temperature of 545 deg. F. at the engine stop-valve. The engine speed was 83·74 r.p.m. and the torsionmeter indicated the transmission of 1,939 h.p. to the propeller shaft, this reading, in conjunction with the indicated horse-power, showing a mechanical efficiency of 91·2 per cent. The feed water had a temperature, after the second stage, of 288 deg. F. The condenser vacuum was 25·75 in. Hg.

As regards combustion conditions, the air was supplied to the furnaces at a temperature of 245 deg. F. The fuel oil had a specific gravity of 0·950 at 60 deg. F., and a viscosity of 719 seconds Redwood No. 1 at 100 deg. F.; the gross calorific value was 18,727 B.Th.U. per pound. The barometer stood at 30·05 in. Hg. It would appear that no readings were taken of either the funnel draught or the CO_2 content. The water consumption, for all purposes, was 10·87 lb. per indicated horse-power and the fuel consumption was 0·766 lb. per indicated horse-power per hour. The equivalent oil consumption per shaft horse-power per hour for all purposes was 0·84 lb. These figures give a thermal efficiency for the boilers of 82·9 per cent. The speed of the vessel during this trial was 11·9 knots by log. On her maiden voyage, she developed a speed of 11·65 knots, with a mean apparent slip of 3·62 per cent., on a mean displacement of 10,402 tons and a mean draught of 23 ft. 6½ in. The oil consumption per indicated horse-power per hour for all purposes was 0·791 lb. and the engines developed a mean indicated horse-power of 2,076. The results from the maiden voyage and from the special trial may thus be regarded as satisfactorily consistent.

2,000-TON PRESS FOR CHASSIS FRAMES.

MESSRS. VICKERS-ARMSTRONGS LIMITED, LONDON.



2,000-TON ECCENTRIC-OPERATED PRESS.

The large press illustrated on this page has been constructed by Messrs. Vickers-Armstrongs Limited, Newcastle-on-Tyne, at their Elswick works, for the manufacture of the chassis frames of heavy road vehicles. It has the high capacity of 2,000 tons and is of notable dimensions. The width between the columns is 25 ft., this being also the length of the bed, which is 5 ft. 4 in. wide. The slide to which the top die is attached is 24 ft. 2 in. long by 4 ft. 2 in. wide, and has a stroke of 18 in. The slide can be adjusted in position relative to the end of the stroke by 20 in., this adjustment permitting a wide variation in the depth of the dies used. The overall height of the press is 35 ft. and its total weight is 220 tons. The bed, the two side columns and the top cross-beam are all of welded steel plate, the largest single part being the bed, which weighs 62 tons. The bed houses five air-operated die cushions. The overall length of the bed opening is 23 ft. 8 in., this dimension including the four ribs which divide the opening into the five sections required. The width of the opening is 3 ft. 4 in. With an operating air pressure of 100 lb. per square inch, the five die cushions are capable of absorbing approximately 400 tons of the total load. To ensure accurate operation, the cushions are guided for the full length of the stroke and bronze wearing strips are provided.

The columns, top cross-beam and bed are tied together vertically by four heavy steel bolts, one at each corner. The cross-beam, which contains the slide-operating gear, is of box type and forms an oil bath in which the gear runs. The main shaft of the gear is driven by V-belts from a motor developing 75 h.p. at 1,500 r.p.m., the transmission to the eccentrics actuating the slide plungers being geared down so that the slide makes 6 strokes per minute. The transmission includes a balanced flywheel and an air-operated electrically-controlled friction clutch. The main bearings are carried in steel castings which are welded to the plating of the cross-beam; they have bronze liners and are lubricated from an electrically-driven high-speed pump drawing from the cross-beam oil bath. The slide being operated by eccentrics, the machine is of the crankless type; the two slide plungers are just distinguishable between the top of the slide and the bottom of the cross-beam, one on each side. Below them is the bevel gear and adjusting screws, this gear being operated by an independent 10-h.p. motor situated inside the slide. The four cylinders seen between the plungers above the slide are for counterbalancing the weight of the slide and its attached dies. Control of the press through the electrically-operated clutch is effected by means of a rotary-type cam limit switch, a contactor panel, selector switches and push buttons by which the various motions are started and stopped being provided. The machine is known as the British Clearing press, Messrs. Vickers-Armstrongs co-operating in the design with the Clearing Machine Corporation, Chicago, Illinois, U.S.A.

The Chemical Society.—The 1947 Tilden Lecture of the Chemical Society will be delivered by Professor E. G. Cox, D.Sc., at the Society's rooms, Burlington House, Piccadilly, London, W.1, on Thursday, October 23, at 7.30 p.m. Professor Cox has chosen for his subject "Crystallographic Technique and Its Chemical Significance."

TESTING LOCOMOTIVES ON THE TRACK; L.M.S. RAILWAY.

Fig. 1. Train Equipped with Testing Apparatus.

LOCOMOTIVE-TESTING VEHICLES; L.M.S. RAILWAY.

In the past, locomotives of the London Midland and Scottish Railway Company have been tested on the track by using a dynamometer car between the engine and train, to measure and record speed, tractive effort and the work done in relation to the quantities of coal and water consumed; but before the war, construction of a stationary test plant at Rugby was initiated jointly by the L.M.S. and the London and North Eastern Railway Company. Unfortunately, the completion of the Rugby plant was postponed owing to the war. Both methods of testing have their special advantages and disadvantages, which were described by Sir William Stanier, F.R.S., in his presidential address* on "The Position of the Locomotive in Mechanical Engineering," delivered to the Institution of Mechanical Engineers, in London, on Friday, October 24, 1941.

After referring to the fact that the results obtained from dynamometer-car tests are not independent of variations in running resistance, and that due regard must be paid to the composition of the train, weather conditions, and nature of route traversed, Sir William said that, although many of the large and more obvious savings in fuel consumption have been made after studying the data furnished by dynamometer cars, "from now onwards each forward step will not only be more difficult to obtain mechanically, but its cost is likely to be high enough to make a very close estimate of the saving essential. For this reason, more exact experiments are necessary, and two methods of approach can be followed. One takes the form of a stationary testing plant, and the other involves the use of mobile apparatus." He compared the practical difficulty of obtaining reliable indicator cards and accurate measurements of the water consumption while the locomotive was running in service, with the accurate results of constant-speed testing which would be obtained from a stationary plant. After referring to the late Sir Nigel Gresley's advocacy of a stationary plant, and the position with regard to the one at Rugby, he presented the case for mobile apparatus which would "carry the matter a stage beyond the consideration of thermal efficiency alone. It is necessary," he said, "to couple that efficiency with actual operating conditions, and this is an aspect of the matter which can only be truly evaluated on the road. I refer particularly to the possibility of modifying train loads and schedules so as to ensure that the engines are always working as nearly as possible at their condition of maximum efficiency. . . . While the curve (relating efficiency to power output) for a modern steam locomotive is flatter than for alternative forms of power, there is none the less an optimum rate of working, and to explore the application of this factor to traffic conditions is also a matter for experiment." Although variable-speed dynamometer-car tests had been used to investigate this aspect—they had, for example, formed the basis of the working schedules for the Coronation Scot train, and the Midland Division accelerations of pre-war days—it was proposed, by means of constant-speed testing on the track, to build up characteristic curves of the most economical performance under every condition of working for each class of engine.

* Engineering, vol. 152, page 357 (1941).

Sir William then referred to the development, on the Continent, of the brake locomotive to maintain constant speed over the test run, and he continued: "Instead of using an old steam locomotive for the purpose, it is proposed on the London Midland and Scottish Railway to use electrical braking vehicles, known as mobile testing units." The construction of three such vehicles was authorised in 1936 and practically completed in 1939, and they were used during the war as emergency power generators. They are now being reconditioned and will be used for their normal purpose; one of them is shown behind the tender in a recent test run, in Fig. 1, on this page. The L.M.S. have furnished a description of them and of a new dynamometer car and tender which will be used in conjunction with them. The company point out that in certain countries, such as Germany, Poland and Russia, there are long stretches of practically level and straight track on which tests can be carried out, but that in this country such facilities are difficult to obtain. For example, on the Euston-Rugby main line, which is probably the most suitable stretch on the L.M.S., the gradients would make it difficult to maintain constant speed, even by using braking locomotives. The electrical-braking mobile test units, however, are designed to maintain a constant speed by automatically varying the tractive resistance of the train to counteract the effect of gradients, etc.

The complete mobile testing plant will comprise three braking units for maximum speeds of 50, 90 and 120 miles an hour, respectively, one of which is illustrated in Fig. 2, on page 324, a dynamometer car and a special tender, neither of which is yet completed. Tests are being carried out, however, using the low-speed unit, and one of the company's existing dynamometer cars, which is being equipped with master controls and other apparatus for this purpose. Each braking unit is a coach with two four-wheeled bogies, each axle driving a generator, the electrical output from which is dissipated in large resistance grids, which are placed in two vertical ducts up which cooling air is blown by motor-driven fans. The heat is thus imparted to two columns of air which are expelled vertically through openings in the roof. These openings are protected by sliding covers when not in use. As the full power of the generators may be required at very low speeds, they are cooled by motor-driven centrifugal fans; and the auxiliary power which is required for the resistance fans, the cooling and excitation of the generators, and other purposes, is provided by a generator-set comprising an A.E.C. 100-h.p. Diesel engine and generators fitted in the middle section of the vehicle, and illustrated in Fig. 5, on page 324. One of these generators is connected in parallel with a 120-ampere-hour battery which provides power in an emergency, and supplies current for heating and lighting when the generator set is not running.

Each axle generator is rated at 375 h.p., so that each coach will absorb 1,500 h.p. The three testing vehicles are generally similar, but have different gear ratios between the axles and generators, allowing maximum speeds, as already noted, of 50, 90 and 120 miles an hour, for testing different classes of locomotives. They may be used singly or in any combination, and together will give a maximum braking effort of 23 tons. A bogie with two generators is illustrated in Fig. 3, on page 324. In the bogies of the low-speed unit the generators have suspension bearings and are supported by the axles as in a normal motor coach. Owing to the weight of the generators, however, it is undesirable for a similar arrangement to be used for the higher speed units, as the large unsprung weight on the axle would tend to damage or severely wear the track. The generators of the medium- and high-speed units are therefore supported directly on the bogie frames by brackets, and the generator shaft is geared and connected to the axle by means of Andrews-English Electric flexible drives, which were made by the L.M.S. under licence. These drives, which were developed for use in high-powered motor coaches, permit free movement of the axle vertically. They are self-aligning and allow some lateral movement for clearances in the axleboxes or distortion of the bogie frame.

For maintaining constant train speed an automatic control, which regulates the loading of the main generators, has been designed. On the dynamometer car which will be used in conjunction with the braking units, a small tachometer generator is driven from an unflanged wheel riding on the rail, and generates a voltage which is proportional to the speed of the train. This is balanced against a fixed voltage representing the speed to be maintained, so that the difference represents the error between the actual and the required speeds. This voltage is amplified and transmitted down the train to the braking units, in each of which is a thyratron rectifier set controlling the main-generator excitation. Stabilising devices are provided to prevent the various forms of hunting which would otherwise occur. Each unit has also a master control so that it may be operated independently of the train, if desired. The principal controls of each braking unit are situated in a compartment at one end of the vehicle, as shown in Fig. 4, on page 324.

The new dynamometer car will be a double-bogie coach with an additional unflanged wheel on the leading bogie, for the purpose already described, and for accurate measurement of the speed and the distance travelled. It will contain an Amsler hydraulic dynamometer,

which will be coupled to the leading draw-hook through a friction draw-gear, and provided with a recording table which will give a continuous record of drawbar pull, speed, work done, etc., on a time or distance basis. The master controls for the three braking units will be fitted in a desk panel, and instruments will indicate the loading of each unit. Another panel will carry instruments, such as temperature indicators, for observing the operation of the locomotive. The special tender, which will be suitable for any standard locomotive, is intended for measuring the rates of consumption of coal and water. Three tons of coal, previously weighed out into hundredweight bags, will be carried in a compartment and brought forward when required. Another three tons of loose coal will be carried in a normal bunker for use other than during tests. The tank will contain 3,500 gallons of water, and the feed from the tender to the locomotive will be measured by a displacement-type water meter. A corridor will connect the front of the tender to the dynamometer car, to provide access to the footplate from the testing vehicles during the run.

During 1939, several series of tests were carried out on a Class 4, 0-6-0 freight locomotive on the Derby-Leicester-Burton circuit, and further tests were in hand at the outbreak of hostilities. Measurements of the resistance at constant speeds of a number of coaches of standard type are now being made on the line between Rugby and Peterborough. Fig. 1, on page 321, shows one of these test trains. The order of the vehicles is: locomotive, tender, braking vehicle, dynamometer car, and eight coaches, the tractive resistance of which is being measured. The speed and direction of the resultant wind are measured by a cup anemometer and a vane carried on a light structure on the front of the engine, and are recorded electrically on the dynamometer chart.

The basic principles of the braking units were evolved by Dr. H. I. Andrews, of the L.M.S. Research Department, and development and construction were carried out jointly by the Chief Mechanical Engineer of the L.M.S., who built the vehicle in the Derby works, and the British Thomson-Houston Company, Limited, Rugby, who supplied the main electrical and control equipment.

LAUNCHES AND TRIAL TRIPS.

M.S. "HUNTINGDON."—Twin-screw refrigerated and general cargo vessel, built and engined by Messrs. Alexander Stephen and Sons, Limited, Linthouse, Glasgow, for the Federal Steam Navigation Company, Limited, London. Main dimensions: 560 ft. by 70 ft. by 47 ft. 6 in.; deadweight capacity, 14,300 tons on a draught of 32 ft. 6 in. Two Stephen-Doxford Diesel engines developing 12,800 brake horse-power, to give a service speed of 17 knots. Launch, September 16.

S.S. "MATADIAN."—Single-screw vessel for the carriage of palm oil and general cargo, built by Messrs. Sir James Laing and Sons, Limited, Deptford-yard, Sunderland, to the order of The United Africa Company, Limited, London. Main dimensions: 410 ft. by 56 ft. 6 in. by 29 ft. 3 in. to upper deck. Triple-expansion engine of reheat design supplied by Messrs. The North Eastern Marine Engineering Company (1938), Limited, Sunderland, to give a service speed of 11½ knots. Launch, September 16.

M.S. "LA HEVE."—Single-screw general cargo vessel built and engined by Messrs. Harland and Wolff, Limited, Govan, Glasgow, for the French Government. Main dimensions: 395 ft. by 55 ft. by 33 ft. 6 in. to shelter deck; draught loaded, 22 ft. 3 in.; gross tonnage, 4,450. Harland-B. and W. ten-cylinder two-stroke single-acting Diesel engine. Trial trip, September 17.

M.S. "RIO SEGUNDO."—Single-screw grain and general cargo vessel, built by the Burntisland Shipbuilding Company, Limited, Burntisland, for the Argentine State Shipping Company (Flota Mercante del Estado), Buenos Aires. Main dimensions: 425 ft. by 57 ft. by 37 ft. 9 in. to shelter deck; deadweight capacity, 9,450 tons on a draught of 25 ft. 9½ in. Doxford-type four-cylinder opposed-piston two-cycle Diesel engine of 3,300 brake horse-power, supplied by the North Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne. Trial trip, September 25.

S.S. "HELKA."—Single-screw general cargo vessel, built by the Burntisland Shipbuilding Company, Limited, Burntisland, for the Euxine Shipping Company, Limited, London. Main dimensions: 312 ft. by 44 ft. 6 in. by 29 ft. 1 in. to shelter deck; deadweight capacity, about 3,650 tons on a draught of 19 ft. 9 in. Triple-expansion engine supplied by Messrs. Hall, Russell and Company, Limited, York-place, Aberdeen. Launch, September 27.

M.S. "GANDA."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Company, Limited, Burntisland, for the Companhia Colonial de Navegaçao, Lisbon. Main dimensions: 425 ft. by 59 ft. by 38 ft. to shelter deck; deadweight capacity, about 9,000 tons. Doxford four-cylinder opposed-piston Diesel engine. Launch, September 30.

SYMPOSIUM ON INTERNAL STRESSES.

THE Institute of Metals, 4, Grosvenor-gardens, London, S.W.1, in association with the Faraday Society, the Institute of Physics, the Institution of Mechanical Engineers (and their Automobile Division), the Iron and Steel Institute, the Physical Society, and the Royal Aeronautical Society, are holding a Symposium on Internal Stresses in Metals and Alloys, at the Institution of Mechanical Engineers, Storey's-gate, Westminster, London, S.W.1, on Wednesday and Thursday, October 15 and 16. The symposium consists of 36 papers and these have been divided into three main sections, the first of which is entitled "The Measurement of Internal Stresses." Section II deals with "The Origin, Control and Removal of Internal Stresses," and Section III with "Effects Associated with Internal Stresses." To allow the maximum time for discussion, papers will not be presented by individual authors, but will be summarised, at the commencement of each session, by *rapporteurs*, who will indicate those points on which they consider that discussion will be most profitable.

The programme has been arranged as follows. At 10 a.m., on Wednesday, October 15, Colonel P. G. J. Guesterbock, C.B., D.S.O., M.A., President of the Institute of Metals, will deliver an introductory address, after which Dr. C. Sykes, F.R.S., will take the chair for Section I. Mr. D. A. Oliver, *rapporteur* for the Section, will deal with the five papers included, which are by Dr. H. Ford, Mr. R. King, Mr. D. E. Thomas, Dr. W. A. Wood and Dr. H. Lipson. The meeting will be adjourned at 12.30 p.m. At 2 p.m., Professor Leslie Aitchison will take the chair for Section II, and the *rapporteur*, Professor H. O'Neill, will summarise the 16 papers in the Section. The authors include Dr. E. Orowan, F.R.S., Dr. M. Cook, Dr. H. Ellias, Mr. J. E. Russell, Mr. A. W. Hothersall, Dr. F. P. Bowden, Mr. M. C. Caplan, Mr. G. Forrest, Dr. W. Betteridge, Mr. J. C. W. Humfrey, and Mr. D. G. Sopwith. The meeting will be adjourned at 5 p.m., and a conversazione will be held at 4, Grosvenor-gardens, London, S.W.1, at 8 p.m. that evening.

The whole of Thursday, October 16, will be devoted to Section III, which has been divided into two sub-sections, *a* and *b*, dealing, respectively, with "Microscopic and Sub-Microscopic Effects," and "Macroscopic Effects." Sub-section *a* includes nine papers which will be considered from 10 a.m. to 12.30 a.m., the chairman being Dr. M. Cook and the *rapporteur*, Dr. A. G. Quarrell. The authors of the papers in the sub-section include Sir Lawrence Bragg, F.R.S., Professor F. C. Thompson, Mr. F. R. N. Nabarro, Professor J. H. Andrew, and Dr. F. P. Bowden. The six papers in sub-section *b* will be dealt with at the afternoon session on October 16, from 2.30 to 5.0. The chairman will be Dr. H. J. Gough, C.B., F.R.S., and the *rapporteur* Dr. N. P. Allen. The papers are by Dr. U. R. Evans, Mr. W. P. Rees, Professor H. O'Neill, Mr. E. H. Bucknall, Dr. J. A. Wheeler, and other authors.

BOOKS RECEIVED.

Modern Gas Turbines. With Special Reference to Stationary, Aircraft, Locomotive and Marine Types, and to the Supercharging of Internal-Combustion Engines. By ARTHUR W. JUDGE. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 28*s.* net.]

Ministry of Town and Country Planning. Circular No. 29. *Notation for Survey Maps. Including Colour Chart of the British Colour Council.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* net.]

The Electron Jubilee Exhibition. Held at the Science Museum, London, September, 1947, to January, 1948, to Illustrate the Discovery of the Electron in 1897. By D. H. FOLLETT. The Secretary, The Institute of Physics, 47, Belgrave-square, London, S.W.1. [Price 1*s.* net.]

The Council of Industrial Design. Second Annual Report, for the Year 1946-47. Offices of the Council, Tilbury House, Petty France, Westminster, London, S.W.1. [Price 1*s.*]

Metal Powder Report. Volume I. Nos. 1 to 12. *September, 1946, to August, 1947.* Edited by W. D. JONES and R. A. HETZIG. Powder Metallurgy, Limited, Commonwealth House, 1-19, New Oxford-street, London, W.C.1.

Department of Scientific and Industrial Research. Radio Research. Special Report No. 15. *Survey of Existing Information and Data on Radio Noise Over the Frequency Range 1-30 Mc/s.* By DR. H. A. THOMAS and R. E. BURGESS. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*s.* net.]

Made in Wales. Classified List of Products and Manufacturers of Wales and Monmouthshire. The Secretary, National Industrial Development Council for Wales and Monmouthshire, 17, Windsor-place, Cardiff. [Price 1*s.*]

PERSONAL.

SIR G. TRISTRAM EDWARDS was re-elected chairman of the Council of the British Shipbuilding Research Association for the ensuing year, at the annual general meeting, held in Edinburgh, on September 30. SIR A. MURRAY STEPHEN, M.C., was re-elected vice-chairman.

MR. ROBERT BELL, C.B.E., M.Inst.T., formerly assistant general manager, London and North Eastern Railway, has been elected an honorary member of the Institute of Transport, 15, Savoy-street, London, W.C.2. Mr. Bell was an ordinary member of the Institute's Council from 1925 to 1928, a Vice-President from 1929 to 1932, and became honorary librarian in 1932, from which position he retired on September 30.

MR. H. S. TASKER, B.A., has been elected chairman of Messrs. Goodlass Wall and Lead Industries, Limited, Limpsfield-court, Oxted, Surrey. He had previously been vice-chairman to the company and now succeeds MR. C. COOKSON.

MR. G. SMELLIE, formerly deputy works manager of the Port Talbot Works, has been appointed works manager in charge of the Margam and Port Talbot works of the Steel Company of Wales, Limited.

MR. F. OVERSTALL, M.I.E.E., deputy city electrical engineer and manager, Peterborough Corporation Electric Supply, since 1945, has been appointed borough electrical engineer and manager, Burton-on-Trent Corporation.

DR. E. C. R. SPOONER, B.E., has been appointed to the Professorship of Mining and Metallurgy at Adelaide University, with which appointment is associated the Directorship of the Bonython Laboratories of the South Australian School of Mines and Industries.

MR. F. W. LEWIS has relinquished the office of managing director of the Perry Barr Metal Company, Limited, Wellhead Foundry, Perry Barr, Birmingham, 20, owing to continued ill health.

MR. R. J. M. WHIBLEY, A.M.I.Mech.E., of The Churchill Machine Tool Company, Limited, Broadheath, near Manchester, has been awarded the Constantine Gold Medal for his paper on "The Production of Flat Surfaces," read last session before the Manchester Association of Engineers.

MR. W. S. WALKER, M.Sc.Tech. (Manch.), has been awarded the Ph.D. degree of Manchester University.

MR. B. J. PILKINGTON, district controller, London Midland and Scottish Railway, Warrington, has been appointed assistant district operating manager, Manchester (Western). MR. T. EAGLESFIELD, assistant, office of the divisional superintendent of operation, Crewe, is to be district locomotive superintendent, Sheffield, and MR. W. BRAMLEY, assistant, office of the divisional superintendent of operation, Derby, has been made district locomotive superintendent, Bletchley.

MR. F. G. BENNETT, M.I.E.E., A.M.I.Mech.E., formerly chief textile engineer to Messrs. Metropolitan-Vickers Electrical Company, Limited, has joined the staff of Messrs. Wm. Allan Smith and Company, Limited, Edinburgh, as technical director.

MR. W. O. SKEAT, B.Sc. (Eng.) (Lond.), A.M.I.Mech.E., joined the British Council's Science Department on September 1 as Editor of *British Science News*, the new journal which is to replace *Monthly Science News*.

MESSRS. DAVID BROWN AND SONS (HUDDERSFIELD) LIMITED, Huddersfield, announce that MR. DAVID BROWN has acquired the goodwill, designs and work in progress of LAGONDA LIMITED. It is probable that the manufacturing resources of Lagonda Limited and of Aston Martin Limited, acquired by Mr. Brown in March, will be amalgamated at Feltham, Middlesex.

The British Electricity Authority have appointed MR. E. R. WILKINSON, M.I.E.E., to be commercial manager and MR. D. W. COATES, C.B.E., M.A., LL.B., to be chief accountant. Mr. Wilkinson has been commercial manager of the Central Electricty Board since October 1937, while Mr. Coates was appointed chief accountant of the Board when it was set up in 1927.

MESSRS. MUSGRAVE AND COMPANY, LIMITED, heating and ventilating engineers, St. Ann's Works, Belfast, have removed their London office to larger premises at Commerce House, 1a, Newman-street, W.1. (Telegraphic Address: "Musgrave Westdo London." Telephone: MUSeum 6725.)

THE LATE MR. T. C. CHRISTIANSON.—We regret to record the death of Mr. T. C. Christianson, which occurred in Edinburgh on Saturday, September 20. Mr. Christianson began his career with the Newcastle Electric Supply Company in Australia and, after holding positions with Messrs. Merz and McLellan and the English Electric Company, joined the switchgear department of Metropolitan-Vickers Electrical Company in 1922. He was elected an associate member of the Institution of Electrical Engineers in 1913, and was transferred to the class of member in 1927.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Outputs continue on a very satisfactory level, being nearly as high as during the peak outputs obtained in the early part of August, namely, about 39,000 tons of ingots and castings a week. Demand has become intensified within the last week, and high-priority business is becoming increasingly heavy. So far, however, the allocations for other purposes have not been appreciably affected. Shipbuilders and engineering establishments have reported good deliveries of plates, sections, and sheets, and ship repairers are notably well covered. The main item of news last week was the fixing of the coke supply for the new blast-furnace which is about ready to start at Clyde Iron Works. This removes part of the serious threat of a raw-material shortage curtailing steel production in this district. Steel scrap is still in very short supply, but if more pig iron can be made available, the scrap crisis may be negotiated without any breakdown in production.

Scottish Coal.—Despite appeals from the Scottish miners' leaders to stay at work, miners in over a dozen Lanarkshire pits struck work last week on a wage grievance of the oncost workers, and some Ayrshire pits came out on the same complaint. The loss of output rapidly mounted to 10,000 tons a day, and the most serious dislocation of supplies witnessed in the Scottish coalfields for several years resulted, threatening to bring large areas of the coalfield to a standstill. As the strikes arise from alleged anomalies in wages, the feeling is that these developments serve to strengthen the case for an overhaul of the whole question, which all well-informed observers know to be overdue, but which the Ministry have avoided on account of the inflammable nature of the problem. It is understood that many pieceworkers are earning much more money than oncost or day-wage men, but that any revision of the one group would lead to fresh demands for increases from the other. The immediate needs of consumers were met from stocks, which have been greatly denuded in consequence. It is now likely that the winter-stock targets, in many cases, will not be reached, as the increasing frequency of strikes, coupled with the absence of any agreement to work additional shifts to relieve the overall shortage arising from the introduction of the five-day week, have completely upset the restocking programme in Scotland.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Larger supplies of coke have permitted the uninterrupted production of pig iron. Steel production is approaching normal now that there is sufficient coal and gas for the operation of the melting and heat-treatment furnaces; but supplies of steel are inadequate for the requirements of the numerous makers of steel products, and it will be some little time before the shortage is overcome, notably in high-carbon and stainless steels. Some American coal, directed to steelworks during the period of the South Yorkshire strikes, was not suitable for the producer plants, and consequently steel production was retarded. Some steel firms have objected to paying the high prices of between 7*l.* and 8*l.* per ton for American coal, and contend that the National Coal Board should bear the difference in price between Yorkshire and American coal. Efforts continue to be made to accelerate deliveries of coal-mining equipment, including steel arches and props, as well as special types of American machinery now being produced in local engineering works for use on open-cast coal sites. District firms, deprived of the colliery section of their enterprise, have planned a wide extension of the range of their engineering products and are carrying out extensions.

South Yorkshire Coal Trade.—Satisfactory production of coal has been achieved since the strikes, and it has been possible to resume normal deliveries. Industrial concerns whose reserves were becoming low are building them up again steadily. Electricity generating stations have almost reached the safety level in coal stocks, but gas undertakings need much more coal. Coke-oven gas is flowing freely again through the South Yorkshire gas grid, and with many coking-ovens operating at full heats, the supply of coke has increased. House coal is needed in larger supply.

INCREASED IRON AND STEEL PRICES.—The Minister of Supply has issued the Control of Iron and Steel (No. 60) (Scrap) Order (S.R. & O. No. 2095, 1947); the Control of Iron and Steel (No. 61) Order (S.R. & O. No. 2096, 1947); and the Control of Bolts, Nuts and Screws (No. 14) Order, all of which came into force on October 1. The Orders increase the maximum prices of scrap iron and steel and of most iron and steel products, consequent upon the increases in freight rates and in the prices of coal and coke. The increases range from 11*s.* a ton for hematite pig iron to 32*s.* 6*d.* a ton for railway laminated and coil springs.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—Reports from Australia that Mr. Robert Foot, chairman of the Powell Duffryn Group, was flying to Brisbane for talks with the Queensland Prime Minister concerning the rich deposits of coal in that State have aroused much interest in the Welsh coal trade. Professor T. David Jones, who was killed in an accident recently, visited Australia a short time ago and brought back enthusiastic reports on the potentialities of the coal deposits there. A spokesman of the company said that no statement could be made yet, either confirming or denying the visit of Mr. Foot. The output from the Welsh mines was higher in the week ended September 20, totalling 448,200 tons, as against 441,000 tons in the previous week and 440,200 tons a year ago. In spite of the steady expansion in production, however, the acute shortage on the steam-coal market is unrelieved. Salesmen have been besieged with more orders than they could cope with, and have had to scrutinise all new business carefully in order to spread available supplies over as many users as possible. The needs of the public-utility and other high-priority home consumers accounted for almost the whole of present outputs, and the demand from these sources is still very heavy, with the result that potential outputs were earmarked for a long time to come. Export business has been almost impossible to arrange as the only supplies available were some anthracites earmarked for delivery to Canada and limited quantities of the steam descriptions which were being spared for delivery to certain users in Eire. No coal was available for ordinary export trading. A steady inquiry was encountered for bunkers.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, the demand for tinplates was fully maintained and that makers had received, from home consumers, a number of orders for delivery during the fourth quarter of the present year. In the export market, the demand was strong, but the quantities available for shipment were not large. Steel sheets are unchanged and the demand continues such that makers are only able to accept high-priority orders for any reasonable delivery.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Both home and overseas users of iron and steel continue to call persistently for much larger deliveries than producers can provide. Customers are extensively bought, bookings in some cases extending as far ahead as June next. Cancellations of contracts due for completion at the end of September were less numerous than seemed likely and a considerable expansion in outputs during the autumn is expected. Buyers have to pay prices ruling at the time of supply and are anxious to place new orders for any delivery sellers are able to guarantee. There is a continued and inconvenient scarcity of ordinary foundry iron and of cast-iron scrap, the shortage of which is still seriously hampering an expansion in production of the much-needed light castings, but a welcome increase in the make of ingots is reflected in improved deliveries of steel billets and sheet bars.

Foundry and Basic Iron.—Better supplies of high-phosphorus pig iron are reaching consumers' works and a further increase in the tonnage distribution is now confidently expected. The local output is rapidly taken up and the larger deliveries from other producing areas are of satisfactory quality. The Tees-side basic blast-furnaces are providing no iron for the market, the whole of the output continuing to move promptly into direct use at the makers' adjacent steel plants.

Hematite, Low-Phosphorus and Refined Iron.—East-Coast hematite manufacturers have as much work as they can handle and sales extend over periods well ahead. Delivery obligations, however, are steadily maintained and an early expansion in output is not unlikely. Firms turning out low- and medium-phosphorus grades of iron are unable to keep pace with the growing requirements of the users, and the position calls for an early substantial enlargement of makes. The output of refined iron is steadily absorbed.

Manufactured Iron and Steel.—Semi-finished and finished iron manufacturers have contracts to carry out that will keep their plants busily occupied for a considerable time and steel producers have embarrassingly large commitments. While steel semies are now less scarce than they have been for some time, re-rollers continue to demand larger quantities than are obtainable, and any available inferior material is quickly taken up. In the finished branches of the steel industry the demand for supplies continues to increase in intensity. Outstanding features are the great expansion in the demand for colliery equipment and for black and galvanised sheets and the heavy bookings for rails.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTE OF ECONOMIC ENGINEERING.—*Midland Region:* Saturday, October 4, 2.30 p.m., Chamber of Commerce, 95, New-street, Birmingham, 2. "Time-Study Allowances," by Mr. S. Walford. *London Region:* Friday, October 10, 7 p.m., Cowdray Hall, Henrietta-place, W.1. "A National Wages Policy," by Mr. C. A. Lidbury.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Lancashire Branch:* Saturday, October 4, 3 p.m., Engineers' Club, Manchester. "Laboratory Control in a Light Alloy Foundry," by Mr. E. J. R. Mitchell. *Wales and Monmouth Branch:* Saturday, October 4, 6.30 p.m., Engineers' Institute, Park-place, Cardiff. "Gating and Risering of Iron Castings," by Mr. G. L. Jones. *Sheffield Branch:* Monday, October 6, 7.30 p.m., Royal Victoria Hotel, Sheffield. Presidential Address on "Economic Aspects of the Foundry Industry," by Mr. B. Gray. *East Anglian Section:* Wednesday, October 8, 7 p.m., Central Library, Ipswich. "Cupola Operation," by Mr. C. A. Payne. *West Riding of Yorkshire Branch:* Saturday, October 11, 6.30 p.m., Technical College, Bradford. Presidential Address, by Mr. D. W. Hammond. "Lost Wax Process," by Mr. F. Hudson.

INSTITUTION OF MECHANICAL ENGINEERS.—*London Graduates' Section:* Saturday, October 4, 3 p.m., Storey's-gate, St. James's Park, S.W.1. "Combustion Research as Applied to the Internal-Combustion Engine," by Mr. W. P. W. Moore. *North-Eastern Branch:* Monday, October 6, 6 p.m., Neville Hall, Newcastle-upon-Tyne. Joint Meeting with the INSTITUTION OF ELECTRICAL ENGINEERS (*North-Eastern Centre*). Parsons' Memorial Lecture on "Parsons: The Man and His Work," by Sir Claude D. Gibb. *Automobile Division:* Tuesday, October 7, Storey's-gate, S.W.1. 5.30 p.m., Annual Meeting. 6 p.m., "Design, Development and Production of High-Speed Compression-Ignition Engines," by Messrs. S. Markland and N. Tattersall. *North-Western Branch:* Thursday, October 9, 6.45 p.m., Engineers' Club, Manchester. "An Axial-Flow Gas Turbine for Jet Propulsion," by Dr. D. M. Smith. *Western Branch:* Thursday, October 9, 7 p.m., Merchant Venturers' College, Bristol. "Mechanical Engineering and Agriculture," by Mr. S. J. Wright.

LONDON ASSOCIATION OF ENGINEERS.—Saturday, October 4, 6.30 p.m., Charing Cross Hotel, W.C.2. "Chemistry for the Engineer," by Mr. R. Rabnott.

INSTITUTE OF TRANSPORT.—Monday, October 6, 5.30 p.m., Institution of Electrical Engineers, Victoria-embankment, W.C.2. Presidential Address on "A New Era for Transport," by Mr. T. W. Royle. *Midland Section:* Monday, October 6, 6.30 p.m., Imperial Hotel, Birmingham. "Indivisible Loads," by Mr. E. Bulgin.

SOCIETY OF ENGINEERS.—Monday, October 6, 5.30 p.m., Geological Society's Rooms, Burlington House, Piccadilly, W.1. "Prefabricated Pre-Cast Concrete Structures," by Mr. C. D. Mitchell.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Mersey Centre:* Monday, October 6, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. Chairman's Address, by Mr. P. C. Barnes. *North Midland Centre:* Tuesday, October 7, 6.30 p.m., Corporation Electricity Dept., Whitehall-road, Leeds. Chairman's Address, by Mr. E. S. Ritter. *North-Western Centre:* Tuesday, October 7, 6.30 p.m., Engineers' Club, Manchester. Chairman's Address, by Mr. R. A. S. Thwaites. *Institution:* Thursday, October 9, 5.30 p.m., Victoria-embankment, W.C.2. Presidential Address, by Mr. P. Good.

INSTITUTION OF PRODUCTION ENGINEERS.—*Yorkshire Section:* Monday, October 6, 7 p.m., Hotel Metropole, Leeds. "Noise and Vibration in Machinery," by Dr. W. A. Tuplin. *Coventry Section:* Friday, October 10, 6.45 p.m., Technical College, Coventry. "American Attitude to Production Modernisation," by Mr. H. H. Beeny.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 7, 6.30 p.m., 39, Elmbank-crescent, Glasgow. Presidential Address by Dr. J. McNeill.

INSTITUTE OF PETROLEUM.—Wednesday, October 8, 5.30 p.m., 26, Portland-place, W.1. "Corrosion and Abrasion in the Petroleum Industry," by Mr. B. B. Morton.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Thursday, October 9, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Bogies and Pony Trucks," by Mr. J. C. Loach.

ROYAL AERONAUTICAL SOCIETY.—Thursday, October 9, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Pressurisation of Aircraft," by Mr. W. M. Widgery.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 10, 6.30 p.m., 39, Victoria-street, S.W.1. "Codes of Practice for Public Works," by Mr. L. P. Walter.

BRAKING VEHICLE FOR LOCOMOTIVE TESTS; L.M.S. RAILWAY.

(*For Description, see page* 321.)

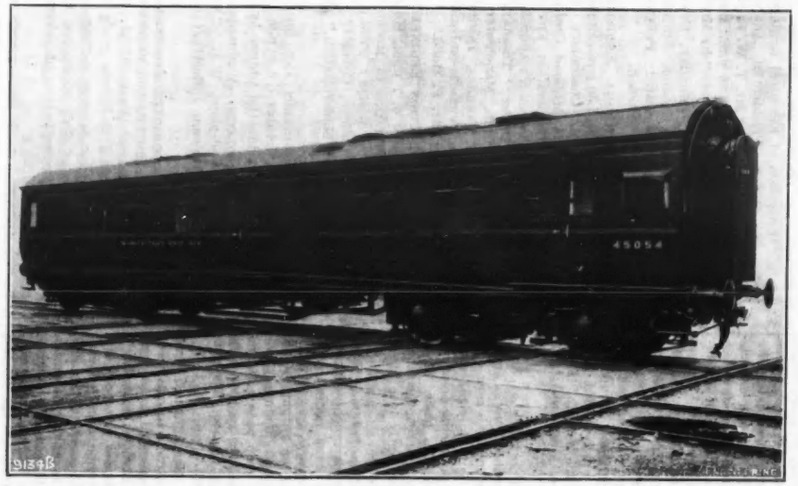


FIG. 2. LOCOMOTIVE-BRAKING VEHICLE.

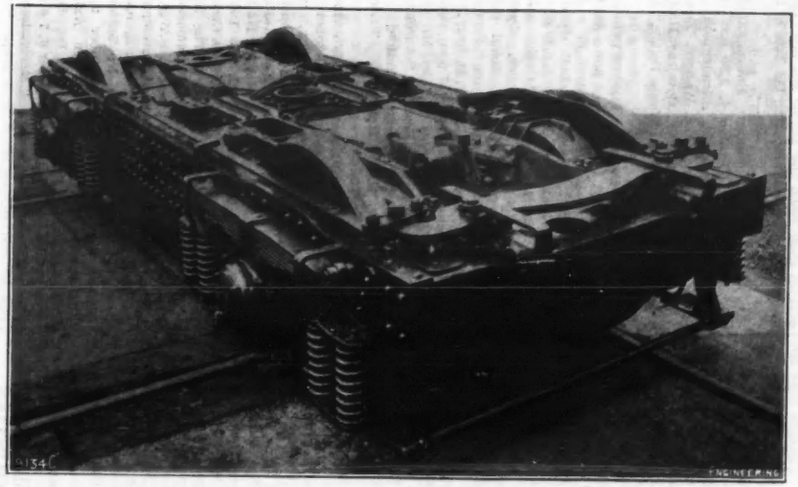


FIG. 3. FOUR-WHEELED BOGIE WITH AXLE GENERATORS.

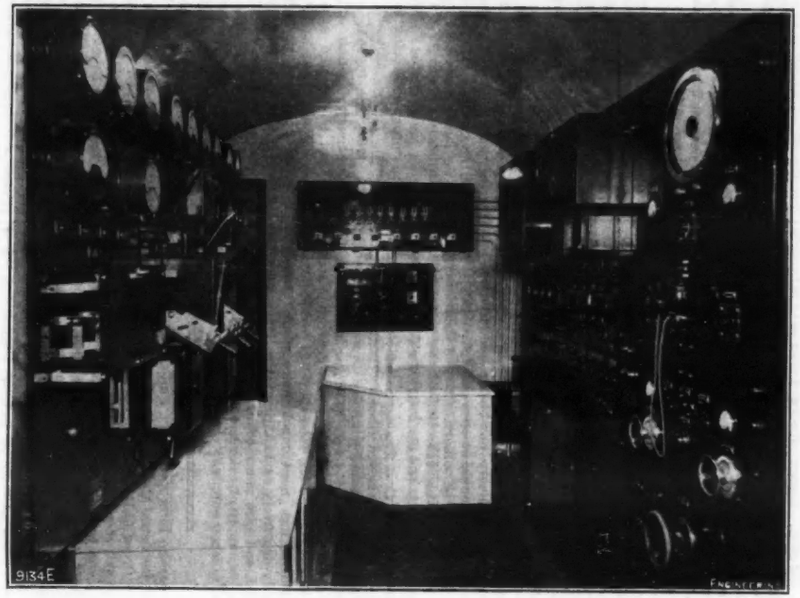


FIG. 4. CONTROL COMPARTMENT.

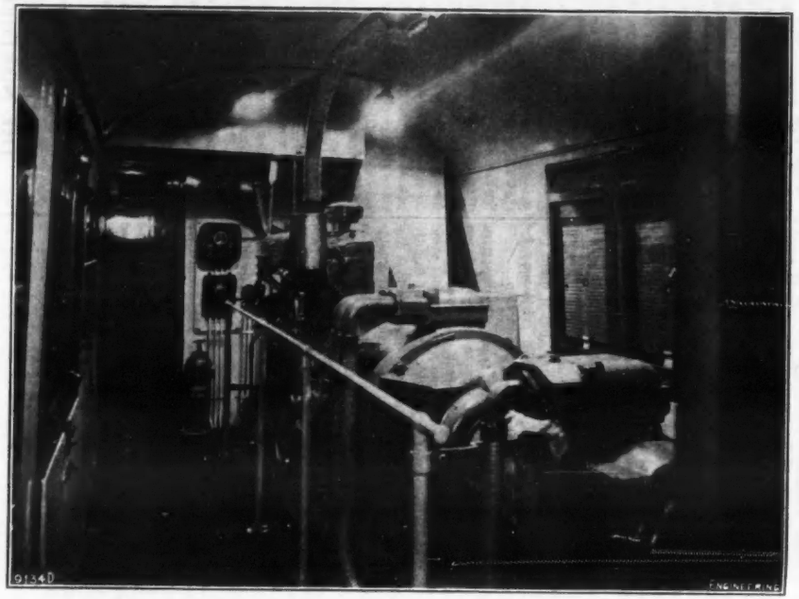


FIG. 5. AUXILIARY GENERATING SET.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

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The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

INDEX TO VOL. 163.

The Index to Vol. 163 of ENGINEERING (January-June, 1947) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, OCTOBER 3, 1947.

VOL. 164. No. 4262.

THE PROBLEM OF ECONOMIC RECOVERY.

THE course of events in this country since Parliament adjourned on August 13 for the summer recess, and the increasing difficulties experienced by most of the European countries and by many outside Europe, do not augur well for the coming winter; but, although provision for immediate needs bulks so largely in the minds of most thoughtful persons in what used to be regarded as the world's premier mercantile nation, the fact remains that future long-term prospects are, or should be, recognised as the more disturbing. Nowhere does it appear that the steps which are being taken to solve economic problems can be expected to provide more than palliatives; assured solutions and permanent re-establishment of economic security are still to seek. On another page we report the expectation, expressed at the recent Fuel Economy Conference at The Hague, that Europe's coal requirements to satisfy domestic needs may be met from internal sources by 1951; but four years more of austerity or worse may well induce conditions that may be beyond the curative powers of a balanced fuel budget or even an apparently restored stability of international monetary exchange.

To the people of Britain, October brings a reversion to war-time restrictions which they had fondly hoped were definitely past: the suspension of private motoring, and of foreign travel unless for urgent business reasons, new curtailments of the supplies of food and clothes, and a re-imposition of Government control over changes of employment. Coupled with these are increased prices of coal (which, however, will not be so severely felt if the coal is not there to be bought); higher transport fares and charges by rail and road; and—a serious blow to the industrialists who are striving so hard to obey the official behest to produce more and export more—increased costs of steel and other materials, in addition to the ever-present threat of new demands for higher wages, with no assurance whatever of any commensurate return. Many of these disabilities may be inevitable in the circumstances, but the most depressing features about them are the virtual certainty that they will be inadequate to obviate yet greater economic stringency, and the knowledge that they could be greatly ameliorated, and perhaps avoided altogether, if only a proper sense of the real urgency of the problem could be instilled into each and all of the working and administrative population of the country.

British industry relinquished much—freedom, investments, markets, and more besides—in the furtherance of the war effort; and relinquished these things cheerfully, in the belief that such sacrifices were essential to continued existence. Always, however, there was a confidence in the eventual outcome and an optimistic view of the future to provide encouragement and stimulate continued endurance. That confidence and optimism are hard to sustain in present circumstances, as a sense of needless frustration grows. Swelling order-books afford little satisfaction when materials to fulfil the orders are not to be had. Schemes to counter the nation's economic peril cannot be expected to evoke enthusiasm when, as often as one Minister of the Crown exhorts the manufacturer to redoubled effort, another arises to deride and threaten him; and when every proposal to impose new restrictions in the sacred name of economy is found to involve the creation of a new staff of officials, with new powers of inquisition and interference, possibly backed by new scales of penalties for failure to observe regulations that are produced almost faster than they can be read.

These are gloomy reflections, admittedly, but no one who is in close and constant touch with the manufacturing industry of this country at the present time is likely to contend that they are gloomier than the reality. We would not suggest for a moment that the picture of the economic plight of Europe presented in the report of the Committee of European Economic Co-operation* was overdrawn, or that a pre-war standard of industrial and commercial well-being can be restored in Britain while half of Europe is struggling for a bare existence; but we do suggest and firmly believe that the nation which has more than once "saved herself by her exertions and Europe by her example" could do a great deal more to help history to repeat itself in this particular direction if some of the present administrative, financial and psychological shackles were removed. And that, we may add, is not a belief that is engendered by mere political bias, of which we have been accused on more than one occasion; the present Government can perform the necessary emancipation as well as any other, if only they have the will and the determination to carry it through. Sir Stafford Cripps, we are confident, will do his utmost, in his new appointment as Minister for Economic Affairs, to restore the national fortunes or, at least, to avoid the threatened economic collapse; but he has several hard rows to hoe, and a notoriously difficult team of husbandmen to handle in the hoeing of them.

The report to which we have referred above, which was prepared for submission to Mr. Marshall, the United States Secretary of State, as a basis for any aid that the United States Government might be able and willing to give to the task of rehabilitating Europe, was signed by the representatives of 16 countries, with an aggregate pre-war population of nearly 206,000,000, headed by Mr. Ernest Bevin, the British representative, who was chairman of the Committee. It has been described in some quarters rather slightingly, as Europe's "shopping list," but in fact it contains some really useful statistical summaries and some notably concise appreciations of the fundamentals of the problem. As an example may be quoted the third paragraph of the first chapter ("Historical Introduction"). "The industrial structure of Western Europe," it states, "was based upon coal, steel and chemicals; its output of these products in the period just before the war was slightly greater than that of the United States. Every part of this machine depended upon the efficient working of the other parts and none of the Western European countries was in a position to organise its industry effectively without the support of the others." To continue with paragraph 7 of

* *Committee of European Economic Co-operation: Volume I, General Report.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* net.]

the same chapter: "In 1945, Europe was perhaps more denuded of resources than at any time in modern history. There was a shortage of all basic materials . . . and, in most countries, of available labour. Some industries began to run down for lack of facilities for all but temporary repair. After the shortage of food, the decline in the production of coal and steel was perhaps the hardest blow to the economy of Europe."

This puts the general position in a nutshell, but it will be appreciated that the condition of individual countries may depart considerably from the mean; for example, even in cases where the proportionate declines in coal and steel production are broadly comparable, the reasons for the declines and, therefore, the possibilities of recovery, may vary between wide limits. It can hardly be argued, for instance, that the reasons for the fall in British coal production are the same as those in Holland or any other country which was in enemy occupation during the war. Dutch production difficulties are mainly physical, yet the coal output of the Netherlands has been restored to something like 85 per cent. of the country's requirements. In the British coalfields, the difficulties are much more psychological than physical in their origin, and no convincing evidence has yet been adduced to show that the present labour force of the coal-mining industry could not produce all the coal necessary to meet home demands if every man were resolved to maintain the pre-war level of individual output.

If the coal were available to meet even the scaled-down allocations on which manufacturers are now expected to base their production schedules, the outlook would be much less depressing than it is; and the provision of sufficient reserve stocks to enable the iron and steel industry to rely confidently on being able to work at their war-time level of output would produce a heartening effect throughout British industry, out of all proportion to the extra effort needed to raise the additional coal. It cannot be supposed that the miners' leaders, or, for that matter, the majority of the coal-face workers themselves, are unaware of this; they have been told often enough of their importance to the community and have shown their awareness of it in presenting their repeated claims for higher wages and privileged treatment, yet another of which is now brewing. They may not appreciate yet, as a body, just how closely the restoration of Europe is linked with the results of their labours; but here again their leaders must have some knowledge of this interdependence and might be expected to admit as much and to adjust their policies accordingly. A general economic collapse in Europe must affect this country as well, producing a situation in which it will be quite useless for the National Union of Mineworkers or any other section of the community to claim special consideration, or, in the event, to be accorded it.

At the moment public attention in this country is concentrated rather on steel than coal, following the announcement yesterday by the Minister of Supply, Mr. John Wilmot, of the new system by which steel supplies are to be rationed out to users and related to the actual performance of individual firms in the export field. Exactly how any such scheme can be expected to encourage the manufacturer or increase overseas sales is far from obvious on the face of the particulars disclosed so far. What is only too clear is that it is going to involve an immense amount of clerical work, yet more returns and statistics (to be required by statute and, therefore, subject to penalties for the non-compliance that, otherwise, the Minister sees some reason to expect), and that it will not produce an ounce more steel. What it will do is to introduce yet more delays and frustrations; retard necessary extensions and even routine maintenance; and place the engineering industry, in particular, in the position of having to continue to use their ageing and deteriorating plant to produce new plant for export to their actual and potential competitors abroad. As a method of restoring the national prosperity, the scheme does not impress favourably. On the contrary, it threatens to put out of business many of the smaller firms who, if not exactly the backbone, are essential parts of the structure of the British engineering industry.

THE JUBILEE OF THE ELECTRON.

The jubilee of the discovery of the electron by J. J. Thomson at Cambridge, in 1897, was fittingly celebrated in London last week at a series of meetings organised by the Institute of Physics and the Physical Society, in association with the Institution of Electrical Engineers. This discovery was an outstanding landmark in the development of physical science, leading, on the one hand, to the revision of existing ideas on the constitution of matter; and, on the other, opening up new fields of theoretical knowledge and of practical application. As Professor J. A. Crowther said in his lecture on "The Early Development of the Electron," which was delivered at the Royal Institution on Thursday, September 25, it is characteristic of any great discovery that once it has been accepted it appears to be obvious; and that properly to appreciate the genius of the discoverer the position from which he started must be examined. It may therefore be recalled that 50 years ago Plücker, Crookes and Perrin had carried out much experimental work on the luminous discharge which occurs when a steady potential is applied to electrodes in a partly evacuated tube; and that a good deal of controversy had arisen regarding the nature of this discharge. Opinion, in fact, differed as to whether it consisted of charged particles of molecular dimensions or whether, since the discharge was not apparently deflected by an electrostatic field, it consisted of wave motions in the ether, analogous to light.

To resolve this question, Thomson repeated Perrin's experiment using a tube in which the metal cylinder that collected the cathode rays, as they were then called, was closed except for a narrow slit. The cylinder was also arranged so that the rays only fell upon it when they were deflected by a magnet. He then found that when this deflection occurred there was a large increase in the charge on an associated electrometer, from which it appeared that negative electrification followed the same path as the rays and was indissolubly connected with them. Thomson also found that the sole reason why these rays had not been deflected by an electrostatic field was that the tube had not been evacuated sufficiently. He therefore concluded that as the cathode rays carried a charge of negative electricity and were deflected by both magnetic and electrostatic forces (as if they were negatively electrified) they were, in fact, charges of negative electricity carried by particles of matter. To decide whether these particles were atoms, molecules or matter in a still more divided state, he measured the ratio of their mass to the charge, and concluded that their mass was very much less than that of an atom. He thereupon suggested that the particles, or electrons, as they came to be termed, might be fundamental units of which all atoms were composed.

Convincing evidence in support of this view soon came from Lorentz. Later, moreover, the picture of the atom took more definite shape when Rutherford, as the result of his experiments on α-particles, suggested that it consisted of a central positively-charged nucleus, with a number of electrons circling round it in fixed orbits. A mechanical picture of the atom, which proved of the utmost value in the development of atomic physics, was thus provided, although this picture has had to be modified in the light of later discoveries. In particular, the nucleus is now regarded as consisting of protons and neutrons with the electrons circling round them, while other particles have been discovered, which, in turn, have led to altered views on the constitution of the neutron. In fact, finality has not been reached and investigations, as Professor R. E. Peierls pointed out in the lecture he gave during the celebrations, are now being made on the structure of the electron itself, as well as into its relationship with other fundamental particles. Much further knowledge may therefore be expected in the future, all of which will have its roots in Thomson's fundamental discovery.

The discovery of the electron has led, of course, to many practical results. A number of these were dealt with during the celebrations and, in particular, formed the subject of an interesting public lecture by Sir Clifford Paterson, at the Central Hall, Westminster, on Thursday, September 25. A well-arranged exhibition has also been staged at the Science Museum, South Kensington, and will remain open for at least three months. This will provide an opportunity, which we hope will be taken, for the general public to learn how closely abstruse scientific theory and technical development may be associated in advancing general well-being. Of the practical results of Thomson's work, the most important is probably the thermionic valve, the action of which, as is well known, depends upon the fact that heated metal emits electrons. This widely employed device has been developed from the effect discovered by Edison, who showed that negatively-charged particles are produced in a heated carbon lamp. Fleming's diode, the rectifying action of which rendered it possible to employ it as a detector of radio waves, followed; while de Forest, by adding a third electrode or grid, demonstrated that the resulting "valve" had amplifying properties and could also be used for generating oscillations. From these discoveries have sprung a large family of valves of great complication, sensitivity and utility which are finding increasing applications, not only for the rectification, amplification and generation of oscillations in wireless and wired communications, but in many forms of measuring instruments. The valve can also be used to amplify direct-current and as a high-speed relay.

Another piece of apparatus associated with Thomson's discovery, the development of which has been as significant as that of the thermionic valve, is the cathode-ray tube. This is primarily due to the fact that it provides us with an instrument in which the moving element consists of a stream of electrons. It is, therefore, virtually free from inertia, so that extremely rapid changes in the quantity under observation are faithfully recorded. The intensity of the bright spot on the fluorescent screen and the deflection of the beam can also be controlled. The result is that impulses separated by an interval as short as one micro-second can be determined and the interval itself measured. The development of radar and all that it involves in many fields is, of course, the outstanding example of the practical application of these properties. The photo-electric effect is yet another example of the application of electronic phenomena to practical purposes. It is used in the cells employed in sound film reproduction, in the electron multiplier, the television camera, and the infra-red image-converter.

The part played by the electron in passing electricity through gases has also resulted in many far-reaching applications. Of these, the most important has probably been the development of gas-discharge lighting. This has produced higher efficiencies, combined in the case of the low-pressure mercury-vapour lamp with the conversion of ultra-violet radiation into visible light by coating the enclosing tube with suitable fluorescent material. Improved colour rendering is also obtained by the use of such lamps. Gaseous discharge is also made use of in the many types of rectifiers now employed for all sorts of purposes, while in another field, the Geiger-Müller counter is an example of this type of application. The motion of electrons in solids is employed in practice in such devices as the copper-oxide and selenium rectifiers, as well as in the selenium cells which are used to measure light intensities. As Sir George Thomson has pointed out, electrons are further used for the study of the very small in nature through the medium of the electron microscope and the electron-diffraction camera, while they are employed for the production of very high voltages in such apparatus as the van de Graaff electrostatic generator, the betatron, the synchrotron, with its variant the microtron, and the linear accelerator.

These then, are a few of the developments, great and small, which have sprung from what at first sight may appear to have been little more than an interesting laboratory experiment evolved out of pure scientific curiosity. That it has proved to be something a good deal more is a tribute to the original discoverer. It should also be a stimulus to those who are now working in both the theoretical and the practical fields.

NOTES.

TRANSATLANTIC FLIGHT BY PILOTLESS PLANE.

ON Monday, September 22, a Skymaster aircraft of the United States Army Air Force landed at Brize Norton, Oxfordshire, having completed the flight from Stephenville, Newfoundland, a distance of about 2,500 miles, in 12 hours without the controls being touched; an event which pressure on our space prevented us from recording in last week's issue. An emergency crew of nine, with five observers, were on board, but, according to a statement issued by the United States Embassy in London, before taking off the plane was set for a completely automatic course for a certain length of time. "It was also set to fly a pre-determined course for a certain length of time as well as to fly successively three different courses at pre-determined times. It flew to a home-station frequency in England, and followed that frequency to a location frequency at Brize Norton, after which it set down its landing gear automatically and made an automatic landing." It is further stated that, after the take off at Stephenville, and the climb to the predetermined altitude, the aircraft's mechanism "homed" on a signal emitted by a ship in the Atlantic. When that was reached the radio frequency was automatically changed to the beam from a second ship, and finally to a third beam emitted from a portable transmitter at Brize Norton. The course was checked as a matter of routine, but it is stated that the controls were not touched by the crew. Although it has not been stated, the equipment used is probably an adaptation of the combined automatic pilot and instrument-landing system developed during the war, with the addition of a device which enables the undercarriage to be lowered. It is also probable that the automatic pilot is that recently designed by the Sperry Gyroscope Company, and known as the Gyrosyn, in which the earth's magnetic field is picked up on a detector, amplified and subsequently used to control the gyro. It may be recalled that a radio-controlled aircraft, the Queen Bee, was first used by the Royal Air Force in 1935. A later type, the Queen Wasp, was also developed. The longest pilotless flight previously reported was by a four-engined American Army transport, which flew 2,000 miles in June, 1947, while in August, 1947, it was stated that an experimental unit had maintained a daily flight over a 350-mile route between Ohio and Maryland without a pilot.

SPREADING THE INDUSTRIAL LOAD.

A notice has been sent to about 1,000 of the 8,000 industrial consumers of the Yorkshire Electric Power Company and its associated concerns giving details of a scheme for spreading the industrial electrical load in the area. It is proposed that this shall come into operation on Monday, October 6. Although all industrial users of electricity are obliged to play their part in relieving the peak loads in respect of supplies drawn from the public mains, the scheme does not apply to supplies drawn from consumer's own resources, or to that part of the consumption which is used for continuous processes if restriction would interfere with production. Such consumers, and purely lighting consumers, however, are asked to transfer every possible usage from peak hours. Consumers such as brickworks need not stagger their working hours for that portion of their load for which daylight is essential, while consumers who can transfer at least one-third of their day load to a night shift (10 p.m. to 6 a.m.) need not stagger their day working hours in addition. Two alternative schemes are suggested for dealing with consumers who do not come within these exceptions. In one—the two-cycle scheme—there is an early period of work from 7 a.m. to 11 a.m. and from 12 noon to 4 p.m., with three hours on Saturday mornings; and a late period from 11 a.m. to 3 p.m., from 4 p.m. to 6.40 p.m., and from 7 p.m. to 9.20 p.m. In the other—the three-cycle scheme—there is an early period from 7 a.m. to 11 a.m., and from 11.45 a.m. to 4 p.m.; a middle period from 7 a.m. to 11.45 a.m. and from 12.30 p.m. to 5.30 p.m.; and a late period from 11 a.m. to 3 p.m. and from 4 p.m. to 8.30 p.m. To operate both schemes the area of the Yorkshire Power Company and its associated concerns has been divided into six districts, which have been carefully chosen to give a close balance of electrical loads. If they elect to operate the two-cycle scheme, consumers in the first three of these districts are asked to work the early period of the cycle during the first week and the late period during the second week, and thereafter the early and late periods in alternate weeks. Similarly, consumers in the other three districts are asked to work the late period in the first week and the early period in the second week, and thereafter alternately. For those electing to operate the three-cycle system, the six districts have been grouped in pairs in which the early, middle and late periods will be worked in rotation.

SHEET AND STRIP METAL USERS' TECHNICAL ASSOCIATION.

Since its inception last year, the Sheet and Strip Metal Users' Technical Association ("Sasmuta") has made steady progress, the number of member firms increasing from about 200 to nearly 300. During the year, technical assistance has been given on numerous occasions, the Association's publication *The Bulletin* was started, and the first branch meeting—the first of many, it is hoped—will be held at Birmingham on Friday, December 5. These facts were given by Mr. W. S. Grainger, the chairman, at the Association's annual dinner, which was held at the Café Royal, Regent-street, London, W.1, on Friday, September 26. Mr. Grainger was responding to the toast of the Association and the sheet-metal industry, which had been proposed by Sir Graham Cunningham, K.B.E. Mr. H. W. Bowen proposed the toast of "Kindred Associations," and Sir William Larke, K.B.E., in responding, emphasised the importance to industry of collaboration in research between related organisations, and suggested that the people of this country would not surmount the present difficulties by "snarling at one another," but only by recognising the privilege of giving, and forgetting the right to take. Mr. Barrington Hooper, C.B.E., a retiring member of Council and one of the Association's first two honorary vice-presidents, proposed the toast of the guests in humorous vein, and Dr. C. H. Desch, F.R.S., in responding, referred to the growth of respect for research, particularly in the steel industry, during the past half-century. The dinner was preceded by the annual general meeting and autumn conference, which were held at the Waldorf Hotel, Aldwych, London, W.C.2, on Thursday, September 25, and Friday, September 26. At the technical sessions of the conference, three papers were presented. Mr. H. R. Brooker gave "A Brief Review of Brazing Processes," Mr. J. N. T. Adcock presented a paper on "The Application of Paint to Metal Surfaces," and a symposium on "Lubrication in Drawing Operations" was prepared by Mr. E. A. Evans, Mr. H. Silman, and Professor H. W. Swift, M.A., D.Sc. The honorary secretary of the Association is Mr. Alastair McLeod, and the address is 49, Wellington-street, London, W.C.2.

MISUSE OF MEMBERSHIP INITIALS OF PROFESSIONAL INSTITUTIONS.

One of the privileges of membership of a professional institution is the right to use certain initial letters indicative of that membership. In the case of the older and more important bodies, this right is granted by Royal Charter, and in any case is jealously guarded. During recent months, apparently, there has been an increase in the wrongful use of such initials by certain persons connected with the electrical industry. We are glad to learn, therefore, that the Council of the Institution of Electrical Engineers are preserving their customary vigilance in this matter; and, in the interests both of the general public and the profession, are making energetic use of all measures open to them to curb this practice. In particular, they endeavour to obtain a satisfactory undertaking from the offender to refrain from such misuse; and when this undertaking is not forthcoming do not hesitate to take proceedings in the High Court for an Order calling upon him to abandon the employment of the initials and to deliver up for destruction any stationery or other printed matter on which they may appear. In this connection we have been asked by the Institution to warn employers to check the claims of prospective employees.

LETTERS TO THE EDITOR.

THE MEANING OF MASS.

TO THE EDITOR OF ENGINEERING.

SIR,—I have just seen Mr. Hugh P. Vowles's letter in your issue of September 19, page 279, wherein he asks for some explanation of the apparent ambiguity of statements referring to energy, matter, mass and inertia. Surely a text-book is not necessary to define these terms or to show their connection one with the other, though admittedly, a full explanation of energy and matter could, and does, form the subject matter of many books.

Inertia is that property of a body which causes it to oppose motion if at rest, or, alternatively, to oppose change of motion if it possesses rectilinear velocity. Mr. Vowles is correct in stating that many text-books give mass as the quantity of matter contained in a body, but this is not now correct. Mass is more correctly stated as the measurement of inertia possessed by a body. Matter can probably be best described as the manifestation of energy. A full explanation of this statement can only be obtained by a study of the present-day theories of the constitution of matter, embracing all the work done by Sir J. J. Thomson and subsequently by many scientists, of which Lord Rutherford was the central star, with a final study of wave mechanics following the theories of De Broglie, Heisenberg, Schroedinger and others. Energy is the driving force of the universe and no one has yet been able to define correctly or to state exactly what it is composed of.

Mr. Vowles refers to the fact that if the speed of a moving body increases, so does its mass. This is correct. This theory had its birth in the theory of Fitzgerald and Lorentz who were able to show that increase in velocity caused decrease in the length of a body and so explained the negative results obtained by Michelson and Morley in their famous experiment relative to the then so-called ether. Einstein supplemented this by showing that as length decreased, so mass increased until, at the velocity of light, length became zero and mass infinite.

Connecting these four terms therefore, a body possessing a certain arrangement of energy in the shape of protons, neutrons and electrons, termed matter, opposes change of state of rest or motion. This is its inertia and the measure of it provides its mass. The greater the energy required to promote motion from the state of rest, the greater the mass. Conversely, the greater the velocity, the greater the energy to change that velocity, so again the greater the mass, until, at the speed of light, no energy is great enough to make a further change, hence the mass has become infinite.

Yours faithfully,

C. HUBERT PLANT,

F.I.M., Assoc. Member Atomic Scientists' Assoc·
Midland Metallurgical Societies,
"Bryn," Park Hall-road,
Walsall.
September 26, 1947.

EFFECT OF CENTRIFUGAL FORCE IN AXIAL-FLOW TURBINES.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of September 19, on page 280, Mr. Pochobradsky again reasons that there is no certainty that free-vortex flow takes place after a nozzle. It is very probable that no turbine has ever given the exact flow for which it was designed, and no amount of reasoning can prove either this or the reverse. All that can be done is to accumulate test results of which, for free-vortex designs, there is quite sufficient evidence to give full confidence in that type of flow, and to refute the suggestion in Mr. Pochobradsky's original article that it "would result in substantial reduction in efficiency."

Yours faithfully,

J. H. C. ATKINS,
M.A., A.M.I.Mech.E.

199, Beechwood-avenue,
Coventry.
September 29, 1947.

[This correspondence is now closed.—ED., E.]

OBITUARY.

DR. B. C. LAWS, Wh.Ex.

We have learned with regret of the death, on September 17, at his home in Sutton, Surrey, of Dr. B. C. Laws, who was associated for many years with Lloyd's Register of Shipping as a ship surveyor, research officer, and, after his retirement from whole-time service, as a consultant on research of various kinds. He was 77 years of age.

Bernard Courtney Laws was born on August 25, 1870, at Portsmouth, and received his general education at a school in Southsea. He entered Portsmouth Dockyard in 1886 and served an apprenticeship of rather more than six years under the supervision of H. E. Deadman, then Chief Constructor and subsequently Assistant Director of Naval Construction. In the last year of his apprenticeship he was on the staff of R. E. Froude at the Haslar experiment tank, and in the same year obtained a Whitworth Exhibition. This, in conjunction with a National Scholarship, enabled him to spend three years at the Royal College of Science, which conferred on him the diploma of associateship in engineering in 1895 and in physics and mathematics in 1896. On leaving the College, he joined the ship-design staff of the Fairfield Shipbuilding and Engineering Company, eventually taking charge of their research work. In 1899, he was appointed naval architect to the Chantiers Navals de Nicolaieff, on the Black Sea, remaining there for three years.

On his return to England in 1901, Mr. Laws joined the staff of Lloyd's Register as a ship surveyor and spent the following 15 years on ordinary "outport" duties, first at Newcastle-on-Tyne and afterwards at Hull. In 1916, he was transferred to the head office in London, where he was engaged for some years in examining the plans of vessels intended for classification with the Society; but his mathematical skill and his natural flair for research brought him an increasing amount of scientific investigation and for several years before his retirement in 1932 he was almost wholly engaged on such work. An excellent example of his painstaking and practical methods, his scientific insight, and his considerable literary skill is provided by the paper, "Notes on the Behaviour of two Passenger Vessels during a Voyage to and from Australia," which he contributed to the Institution of Naval Architects (of which he was a member for nearly 40 years) in 1930. He carried out a number of bad-weather observations of the behaviour of ships, on behalf of Lloyd's Register, with a pertinacity that his quiet manner and not exceptionally robust physique would hardly suggest on casual acquaintance.

After his retirement, Dr. Laws (as he became in 1920, the degree being the D.Sc. in Engineering of the University of London) opened a consulting practice in Westminster, where he continued as a researeh consultant to Lloyd's Register and also acted in a similar capacity for the Tungum Alloy Company. Throughout his life, he maintained his scientific interests, being an active member of the London Mathematical Society as well as of the Institution of Civil Engineers and the Institute of Physics, of which he was a Fellow. In addition to various papers presented to the institutions mentioned, Dr. Laws was the author of a book, *The Equilibrium and Stability of Floating Bodies*, published in 1914. His contributions to the science of naval architecture, which led to his London doctorate in 1920, were further recognised in 1932 by the University of Paris, which conferred upon him the degree of Docteur-ès-Sciences.

MR. T. WALLEY.

As we go to press, we have heard with deep regret of the death, on October 1, after a very short illness, of Mr. Thomas Walley, for more than 20 years a valued member of the editorial staff of ENGINEERING. For some time, Mr. Walley's health had not been good, but it seemed to give no special cause for anxiety when he left the office on Friday last for a short holiday in Devon. An outline of his career will appear in next week's issue.

THE FUEL ECONOMY CONFERENCE.

(*Continued from page* 281.)

We continue below our summary of the proceedings of the Fuel Economy Conference held at The Hague, under the auspices of the World Power Conference, from September 2 to September 9. The preceding instalment of our report dealt with the organisation of the Conference and the survey, by Dr. W. Lulofs, of the papers in which the subject of "Fuel Economy since 1939" was discussed by reviewers from 19 countries. This survey was presented on the afternoon of September 2 and was followed, at the same session, by Section A1 of the programme, in which, under the heading of "General," four papers were submitted by contributors from the United States, Britain, France and Canada. It should be mentioned that the papers before the Conference (which had been circulated in advance to the participants) were divided into three broad categories, those in "A" dealing with Production, those in "B" with Distribution, and those in "C" with Utilisation.

General.

The *rapporteur* of Section A1 was Ir. T. P. W. Karreman, of the Electricity Supply Division of the Netherlands Ministry of Economic Affairs, who described his report as being essentially a supplement to the survey already presented by Dr. Lulofs (summarised on page 281, *ante*). The annual production of fuel, he said, had decreased during the war, especially in the enemy-occupied territories, but, while the main causes of this decline were no longer important, there were other factors of a more permanent nature which were significant; notably, shortage of materials and equipment, plant deterioration and increased cost of maintenance, and psychological influences which reduced the productivity of labour. These factors, however, were not wholly adverse, because they emphasised the need to find new and better ways of production, combining a reduction of effort with improved working conditions and the use of fewer raw and basic materials. These problems were not restricted to the sphere of fuel, but they were of especial importance in that sphere because fuel supply constituted a bottle-neck in almost every industry. In this respect, Mr. Karreman continued, the British Coal Survey, discussed in the paper by Dr. A. Parker and Mr. A. C. Maries, provided a particularly good example of what could be achieved; not only did it promote more efficient methods of mining (including the working of opencast coal) by physical and chemical investigations of coal seams, but it encouraged a more economical use of fuel and the application of particular types to particular purposes. The utilisation of waste products also received attention, and a scheme had been drawn up for the production of coal for the next 100 years.

The fuel position in Canada was quite different because there were reserves of water power, oil and natural gas as well as coal. Canada imported much coal, but that was mainly for reasons of quality. The long distances in Canada were such an important factor that the railways used about a quarter of the total consumption of coal; great efforts were being made, therefore, to improve the efficiency of the locomotives. Natural gas had been little used, mainly because the supplies were inconveniently situated; unlike those in the United States, where 3 per cent. of the known reserves of natural gas were consumed in 1946. This did not mean, however, that the natural gas in the United States would be exhausted in some 30 years' time, because the 1946 estimate of gas reserves had been increased since by about 11 per cent. Water power was very important in Canada and provided more energy than could be obtained from the Canadian production of coal. This contrasted sharply with the position in France, where only 1½ per cent. of the energy required was obtained from water power. France suffered severely from drought during the war, so that hydro-electric power production fell by 20 per cent. It was expected that, by 1951, Europe would be producing enough coal to meet the home demands; but the electricity situation was less favourable, because the plant was inadequate while consumption would be greatly increased. Attention was drawn to Austria's considerable water-power resources, as yet unused; and to the project in hand in Eire, to supply the whole country with electricity by using peat as fuel.

The presentation and discussion of Mr. Karreman's report concluded the technical business of September 2. On the following morning two sessions were held concurrently, these dealing with Sections A2 (Solid Fuels) and C2 (Industrial and General Applications); and in the afternoon, also concurrently, two more, namely A3 (Liquid Fuels) and C3 (Domestic and Quasi-Domestic Appliances).

Production of Solid Fuels.

Ir. G. J. de Vooys, the *rapporteur* for Section A2, reviewed six papers of which three dealt with the mechanisation of coal mining and the remaining three with the problems of coal treatment. Regarding the use of lignite in Czechoslovakia he observed that this had a very high content of ash and moisture and that the calorific value of the pure organic matter was low; but the concentration of organic matter could be improved by screening out the fines and then drying and treating by the process of "Bertinisation," in which the dried coal was heated in a stream of flue gas saturated with steam at 300 deg. C. This removed part of the oxygen in the form of CO_2 and water, leaving the lignite in a condition resembling charcoal; it was then known as "Berzit" and was a fuel of quite good quality.

After a brief reference to methods of coal-washing (including the Barvoys process of which he was the inventor and which was described in ENGINEERING, vol. 147, page 639, 1939) Mr. de Vooys turned to a consideration of coal-cutting practice. American practice, he pointed out, favoured the room-and-pillar system, which facilitated the use of mechanical loading much more than did the long-wall method, generally preferred in Europe; but whereas, in Britain, 85 per cent. of the seams of 5 ft. or more in thickness were worked with long-wall mechanical cutters, Continental practice was to use mainly pneumatic picks. Opencast and strip mining, which provided 20 per cent. of the United States output, could be used much more extensively in Europe, with the aid of the appliances developed in the United States for the purpose. He expressed the opinion that the exhausting nature of the work of coal-cutting by pneumatic pick and the difficulty of recruiting labour for the mines, which was a general experience, would lead to an extension of mechanical coal-cutting in Europe, except in the case of the soft coals. It was doubtful, however, whether the room-and-pillar system would make much headway in Europe; partly because of difficulties with ventilation, which appeared to be greater than in America, and partly because the greater depth of the European mines—on an average, three or four times that of United States mines—would involve increased loss of coal, since the increased pressure of the roof would necessitate larger pillars to support it. In many Continental mines, too, there was a serious risk of spontaneous combustion if large masses of coal were left exposed to the oxygen in the air.

Industrial and General Applications of Fuel.

Professor L. H. de Langen had a difficult task in summarising the 20 papers submitted in Section C2, which covered subjects so various as furnaces for special fuels, gas-turbine economy, the recovery of low-grade heat, electronic combustion control for steam boilers, metallurgical uses of high-frequency electric furnaces, heat transfer, and the work of the British Boiler Availability Committee in investigating the causes and prevention of deposits on the external heating surfaces of water-tube boilers. It may be remarked that the reports of this committee, which have been reviewed on various occasions in ENGINEERING, attracted much attention and approval among the Continental and overseas engineers present at the Conference.

In reviewing the problems of heat economy, said Professor Langen, it was found that most of them were of a limited character. An example of a "complete problem," as he termed it, was the

recovery of soda in a sulphate paper mill, where the aim was to recover the chemicals from the waste liquor as economically as possible. Where unbleached pulp was produced by the Tomlinson and similar processes, as in Sweden, the mills had become independent of outside fuel supplies. If a mill needed large quantities of hot water (as in the production of bleached pulp), this water was heated by an exchanger, using the heat from the circulating water which, in turn, was heated by the flue gases in a scrubber. Several other examples were given of the use of heat exchangers, sometimes to the extent of almost complete recovery of the low-grade heat that would have been wasted otherwise. The possibility of co-operation between several plants, or between industrial undertakings and a central power station delivering either steam or electric current, was suggested as a suitable field for further fuel economy. Low-grade heat, however, was only one part of the temperature range covered by Professor Langen's summary, which included mention of a recuperator for steel and glass furnaces, developed in Australia and taking heat from flue gases at 2,300 deg. to 3,100 deg. F.; and of a method of obtaining additional power from a gas turbine instead of using a pass-out condensing steam turbine. The flue gases from the boiler were used to heat the compressed air supplied to an air turbine coupled to the compressor which supplied the air. An electric generator was mounted on the same spindle and provided current for various uses about the plant. The exhaust from the air turbine, being still at a high temperature, was returned to the boiler as combustion air; if the temperature was too high for this purpose, the air could be passed through a heat exchanger and the extra heat used, for example, to heat feed water. As an outcome of the consideration of these and other proposals, Professor Langen suggested, as a subject for discussion by the Conference, the question whether the economic optimum conditions (for example, the surface to be adopted in heat exchangers) were tending to change because of alteration of the ratio of first cost to fuel cost.

PRODUCTION OF LIQUID FUELS.

Six of the seven papers presented in Section A3 and reviewed in a general report by Dr. W. H. Zaayer and Mr. P. van 't Spijker, dealt mainly with the sources of liquid fuels or with possible supplementary sources such as the bituminous sands of Alberta, Canada. The seventh paper, by Professor Ir. J. J. Broeze, Director of the Royal Dutch Shell laboratory at Delft, discussed the properties of different types of oil fuel for Diesel engines, boilers and gas turbines from the points of view of the designer and the user of power plants. Professor Broeze noted that the demand was increasing rapidly for light distillates and that this increase might be met in part from synthetic products (*e.g.*, from the Fischer-Tropsch process) in the future. There were possibilities, hitherto largely neglected, of operating Diesel engines and domestic space-heating boilers on the heavier grades of oil; and there was a need to develop the marine gas turbine, using boiler-grade fuel oils, to compete with marine steam and Diesel engines.

The papers on fuel production originated in countries which were poor in natural crude oil, and several of them described developments which, in consequence, had been stimulated by the war-time cessation of normal supplies. In Sweden, shale oil was produced, by various processes, at Närkes Kvarntorp, in a plant built during the war; and Ljungström's electric heating method was also used, the oil being vaporised in the ground. The power consumption by this method was stated to be 6 kWh per litre of oil. In Alberta, light oils were obtained from the bituminous sands; by washing the sand with hot water, a heavy crude oil was recovered, from which the lighter oil was obtained by cracking. This method was wasteful, however, and experiments were being made with hydrogenation. In France, where there was a shortage of practically every kind of fuel, the vacuum distillation of coal tar had been used to some extent, and it was thought possible to produce a very pure synthesis gas by the oxygen gasification of wood. Shale oil was available in small quantities, which might be increased; and the cost might be reduced considerably by using burnt shale in cement manufacture. It was intended, the summary mentioned, to develop the French oil-refining industry considerably in the near future.

Another paper of much interest, by Mr. E. L. Ritman, examined the earth's annual intake of solar energy in the form of carbohydrates, which was calculated to be approximately equal to the energy requirements of the present population of the world, if all conformed to a standard of living which would be generally regarded as high. [This subject was discussed in detail in 1940 by Sir Alfred Egerton, F.R.S., in the 27th Thomas Hawksley Lecture of the Institution of Mechanical Engineers, reprinted in the 150th volume of ENGINEERING.—ED., E.] The summary concluded with a fairly full abstract of the paper by Mr. J. A. Oriel, C.B.E., and Major K. Gordon, C.B.E., describing the hydrogenation plant at Heysham, Lancashire, where aviation spirit was produced from imported gas oil; the eventual output amounted to 300,000 tons per annum of base stock petrol and 48,000 tons of iso-octane.

DOMESTIC AND QUASI-DOMESTIC APPLIANCES.

The survey of Section C3 (which comprised only two papers) was prepared by Ir. H. Th. Baart de la Faille, chief engineer of the Amsterdam gas and electricity supply department, who reached the general conclusions that advances in the construction of gas appliances required the co-operation of the makers and the gas companies; and that most steam-heated hospital equipment could be replaced with advantage by electrical apparatus. Of the two papers, one came from the United States and dealt with the research and testing organisation of the American Gas Association; and the other, from Sweden, discussed the power requirements of hospitals and similar institutions. Mr. de la Faille commented that more information would have been desirable regarding the details of the inspection of gas appliances which received the official seal of approval; in his own experience, special appliances had been made by some firms for show purposes, which were superior to the products on sale to the public. On grounds of economy, he favoured the use of pilot burners, constantly burning, for lighting the main burners of gas ranges, etc., as the presence of the pilot burner encouraged the user to turn off the main burner when it was not immediately required. He noted with some surprise the virtual disappearance of hot-water geysers in the United States; they were widely used in Europe and were certainly more economical and cheaper than hot-water storage boilers. The power requirements of hospitals, etc., had been the subject of close investigation in Sweden and, in the case of an asylum accommodating 950 patients, it was found that the maximum consumption amounted to 3·2 kWh per patient per day. General electrification was advantageous, especially if special tariffs could be arranged, but electric space-heating and water-heating were economical only in special cases. The electric power consumption for sterilising tended to be rather high—as much as 1 kWh per bed per day—though, naturally this varied according to the nature of the treatment.

This concluded the business of the technical sessions on September 3.

(To be continued.)

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—In view of the prevailing national conditions, the Council of the Institution of Heating and Ventilating Engineers have decided to cancel the arrangements to hold a Jubilee banquet and dance on Tuesday, October 7. It has now been agreed to confine the celebrations to technical meetings, and the final arrangements are that, on Tuesday, October 7, at 5.30 for 6 p.m., a special meeting will be held at the Institution of Civil Engineers, Great George-street, London, S.W.1, when Mr. C. G. Carrothers will read a paper on "Practical Relations between Heat and Electric Forms of Energy, with Special Reference to District Heating." On Wednesday, October 8, an autumn Council meeting will be held at 10 a.m., and, at 5.30 for 6.0 p.m., an autumn meeting will be held at the Institution of Mechanical Engineers, Storey's-gate, St. James's Park, London, S.W.1, when Mr. C. G. Vokes will read a paper on "Air Filtration in War as Applied to Peace Conditions."

THE INSTITUTE OF METALS; GLASGOW MEETING.

THE second session of the Autumn Meeting of the Institute of Metals, held in Glasgow, opened at 9.45 a.m. on Wednesday, September 24, at the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent. A brief report of the first session, held on the evening of Tuesday, September 23, at which the Autumn Lecture was delivered by Professor G. Wesley Austin, was given on page 303, *ante*. At the session on Wednesday morning, the minutes of the previous meeting having been dealt with, the President, Colonel P. G. J. Gueterbock, C.B., D.S.O., M.A., announced that, as required by the Articles of the Institute, a number of officers would retire at the annual general meeting in March, 1948, and would not then be eligible for re-election. These included himself as President, Mr. Roosevelt Griffiths, and Dr. J. L. Haughton as vice-presidents, and Mr. W. H. Henman and Mr. Stanley Robson as members of Council. As already notified to the members, the Council made the following nominations to fill these vacancies and to confirm two appointments made by the Council to fill vacancies occurring since the last annual general meeting. These nominations were: as President, Sir Arthur Smout, J.P.; as vice-presidents, Dr. S. F. Dorey, Mr. A. J. Murphy and Mr. H. S. Tasker; as honorary treasurer, Mr. W. A. C. Newman; and as members of Council, Mr. D. F. Campbell, Mr. A. Dando, Mr. T. M. Herbert, Mr. D. P. C. Neave, and Mr. A. R. Powell.

The President then announced that Mr. H. H. A. Greer, J.P., had been elected to a Fellowship of the Institute, and pointed out that the number of the Fellows was limited to 12. He added that Mr. Greer had been connected with the metal industry for over 50 years. He was an original member of the Institute, and had taken a leading part in the formation of the Scottish local section in 1918. He was a member of the reception committee when the Institute first visited Glasgow in 1910, and was honorary secretary of that committee on the Institute's second visit in 1925. In the course of his reply, Mr. Greer stated that some distinguished metallurgists had acted as chairman of the Scottish local section. The first had been Dr. C. H. Desch, F.R.S., while others had been Professor J. H. Andrew, Professor R. Hay, and Professor G. Wesley Austin. Before terminating the business meeting, the President announced that a "Symposium on Internal Stresses in Metals and Alloys" would be held in association with six other societies at the Institution of Mechanical Engineers, London S.W.1, on October 15 and 16, and that the 1948 annual general meeting would be held in London on March 17 and 18. A programme of the symposium is given on page 322 of this issue.

SURFACE EFFECTS DURING ANNEALING OF 70 : 30 BRASS.

The first paper considered was entitled "Surface Effects During the Annealing of 70 : 30 Brass," and was by Mr. Ivor Jenkins, of the Research Laboratories of the General Electric Company, Limited, Wembley. The author stated that copper-zinc alloys, and more especially those containing more than approximately 15 per cent. of zinc, were difficult to anneal fully without surface discoloration. The difficulties were associated mainly with the marked susceptibility of the alloys to oxidation and staining by oxygen-bearing and sulphurous gases, and to the comparatively high vapour pressure of zinc in brass at normal annealing temperatures. Thus, pure zinc was readily oxidised by carbon dioxide and water vapour, and a burnt fuel gas, for example, which contained both of these constituents, would oxidise the common brasses at temperatures above approximately 350 deg. C. Hydrogen would reduce zinc oxide at temperatures as low as 450 deg. C., although the rate of reaction was very slow indeed. In the present paper, the factors which caused the staining of 70 : 30 brass coils during annealing had been investigated on a laboratory scale. It was observed that zinc oxide stains were formed on the inner turns of a degreased brass coil during annealing in cracked ammonia,

and it was shown that a "bloom" was formed on a single brass strip when heated in cracked ammonia at 550 deg. C. The gases evolved from a degreased brass strip, heated *in vacuo*, were found to be mainly carbon dioxide, carbon monoxide, and hydrogen; during this heat treatment, the loss of zinc from the surface resulted in the metal having a rich copper colour.

It had been found that a degreased brass coil could be bright-annealed perfectly by first heating the coil *in vacuo* (4 mm. mercury) up to 500 deg. C., in order to remove absorbed gases, followed by maintaining the coil at 575 deg. C., under static cracked ammonia for long enough to permit sufficient zinc to diffuse to the surface from the interior of the brass. Coils which had not been degreased had been found to be lightly stained after annealing to this schedule, unless the coil turns had been spaced or the coil height did not exceed 1 in. The presence of methyl alcohol in the static atmosphere, during annealing, decreased the rate of the loss of zinc from the surface of the brass. The values of the diffusivity constant for the diffusion of zinc in 70 : 30 brass had been calculated. Typical values of the diffusivity constant D were: $6{\cdot}8 \times 10^{-14}$, at 405 deg. C., $1{\cdot}01 \times 10^{-11}$, at 500 deg. C.; and $1{\cdot}38 \times 10^{-10}$, at 600 deg. C. The activation energy for the process, calculated from the diffusion data, was 46,000 calories per gramme-atom.

Dr. F. A. Champion, who opened the discussion, presented a contribution by his colleague Dr. C. E. Ransley. In this it was stated that it was assumed that similar specimens were used for the gas content determinations as for the diffusivity measurements. On the assumption that such was the case, rough calculations had been made of the contribution of the evolution of surface gases to the total loss of weight of the specimen. Dr. Ransley thought that it would have been preferable to express the gas evolution in cubic centimetres per square centimetre rather than in cubic centimetres per cubic centimetre of metal. Nevertheless, unless an error had been made in the calculation, the loss in half an hour at about 400 deg. C., due to surface gases, was 0·02 milligramme, whereas the total loss amounted to only 0·033 milligramme. No correction appeared to have been made for this, so that the value of the diffusivity constant D at 405 deg. C., was probably in error to the extent of considerably more than 50 per cent.

The next speaker, Dr. A. G. Quarrell, said that those who were engaged on the practical problems of the annealing of brass would be particularly interested in the suggestion that the results might lead to a satisfactory, if somewhat revolutionary, method of bright-annealing brass. The bright annealing of brass was made difficult by the relatively high vapour pressure of zinc at the normal annealing temperature, and, because of this, a static atmosphere and a minimum of idle furnace space were necessary if the losses were to be reduced to a sufficiently low zinc value for practical purposes. If a static atmosphere were used, the annealing pot must be adequately sealed from the air and, therefore, it could be made suitable for vacuum work.

The suggestion that vacuum conditions should be used in the early stages of bright annealing might give rise to misgivings, but considerable strides had been made in vacuum technique in recent years and the production of vacua of the order of 4 mm. of mercury, at a temperature of about 500 deg. C., should present little difficulty, at least in the case of batch furnaces. It had been realised for a long time that rolling lubricants remaining on the metal might affect the nature of the scale subsequently formed, but apparently this was the first time that results had been reported which indicated that it was not possible to eliminate such effects by an adequate degreasing process. It seemed likely that the surface gas content of the brass strip would vary with the nature of the rolling lubricant and, therefore, it seemed that some progress should be possible by paying attention to the nature of this lubricant. If it were possible to devise a rolling lubricant which, on decomposition, gave off a suitable vapour, this might lead to a reduction in the loss of zinc. The time had come for the metallurgist and the oil technologist to get together on this question of rolling lubricant, regarding which there was considerable divergence of views. Another point was that if the surface gas content referred to by the author were due to impurities being rolled in, the effect should apply in the case of other copper-base alloys; yet, apparently, there was no difficulty in the bright annealing of, for example, tin bronzes. Was this due to the fact that there was no reaction between carbon dioxide and tin bronze? This seemed unlikely. Alternatively, was it because the oxidation product in this case was a transparent continuous film? Incidentally, he wondered whether the author had considered the possibility of obtaining selective oxidation in the reduced pressure which he advocated by the adoption of suitable addition elements to his brass. It might be possible to make additions in such a manner as to get selective oxidation, which would prevent the evaporation of zinc without causing the formation of a discolouring film.

Mr. R. Chadwick said that persons interested in the possibilities of bright-annealing brasses commercially would be more interested in a process employing "cracked and burnt" ammonia than in one employing simply cracked ammonia, on account of the smaller cost of the former. It was, he believed, quite feasible now to produce commercially cracked and burnt ammonia which had a content of nitrogen of more than 90 per cent., and only a very small amount of hydrogen, the gas being also virtually completely free from oxygen and water vapour. The author had said nothing about the nature of the rolling oil employed. Possibly he had obtained commercially-rolled brass, and, therefore, had no data available. If, however, he and his co-workers had rolled the brass themselves, they might know something concerning the oil used, and some details regarding this would add to the value of the paper. It would, of course, be quite feasible to employ a sulphur-free lubricant. For example, the commercial transformer oils were free from sulphur, and it would be interesting to know whether, in fact, some considerable improvement would result from the use of such very pure oils.

The next speaker, Mr. D. C. G. Lees, asked the author whether he had examined any pieces of cast 70 : 30 brass. It was generally asserted that brasses did not suffer from hydrogen porosity, in that the considerable vapour pressure of zinc oxide over the molten metal precluded the possibility of hydrogen retention. Yet it was found that the gases extracted contained a very large quantity of hydrogen—something of the order of 80 per cent.—in those samples from which the outer layers had been removed.

Dr. L. B. Pfeil, O.B.E., stated that the question of bright annealing was of great practical importance nowadays. If the strip produced in this country had not a good surface finish, then additional polishing might be required in the case of many of the articles produced from the strip. There was no doubt that labour for the polishing of metal articles was in short supply; it was, apparently, an unpleasant, unpopular job. The metallurgist, therefore, would be called upon more and more to provide semi-finished material such as strip and sheet with increasingly high-grade finish, so as to cut down the labour required for polishing. Mr. W. A. Baker, who spoke next, stated that the author had said that an atmosphere containing methanol, either alone or added to a suitable neutral atmosphere, had the effect of reducing oxidation to negligible proportions. This bare statement rather suggested that the use of methanol was a remedy for the problem under discussion, and he would like to know whether this was, in fact, the case.

Mr. H. H. Symonds referred to the source of the gases in the brass, in view of the pronounced effect on the material of the hydrogen content. He mentioned that the elimination of this hydrogen at an early stage in the manufacture of the material would appear likely to be very advantageous, at all events when the strip was intended for subsequent cold-rolling. Possibly the use of vacuum and cracked-ammonia techniques for the first anneal after initial breaking down, might produce strip which would respond much more satisfactorily to annealing at thinner gauges. Mr. J. W. Jones, the last speaker in the discussion, said that the industrialist element in the Institute membership was greater than the scientific and academic and he sometimes wondered whether the service given by the Institute would not be improved if to many of the papers there were an addendum presenting and discussing the particular industrial interest and application of the more scientific data contained in the paper itself. An ultra-bright anneal was not an absolute necessity for some processes and it was, of course, an added expense. He wondered whether the author's vacuum annealing was really necessary. Would not an atmosphere of an absolutely inert gas, free from carbon monoxide and other deleterious gases, meet the case, instead of all the practical complications of a vacuum? Arising from this, the author had said that the specimen treated in nitrogen was lightly oxidised, probably on account of incomplete purification of the gas. In work of the kind under consideration such a thing as "probably incomplete purification of the gas" was a factor which ought not to have been allowed to enter into consideration.

Mr. Ivor Jenkins, in reply to Dr. Ransley, said that he was perfectly aware of the limitations of the method used in determining diffusivity by this technique. The data were submitted, as he had indicated, merely as an indication of the freedom of the brass surface from oxidation during the vacuum experiments. With regard to a point raised by Dr. Quarrell, the production of a vacuum on an industrial scale in a bright-annealing plant was not at all difficult. At Wembley, the attainment of a vacuum of the order of 1 mm. of mercury in an annealing container taking a charge weight of about 30 cwt. of brass strip had proved quite feasible. He heartily endorsed Dr. Quarrell's remarks regarding lubricants. In their work at Wembley they were very conscious of the harmful effects introduced by lubricants on materials submitted for bright annealing, in both the ferrous and the non-ferrous metal fields. They had attempted to get together with oil technologists on this problem but, so far, had not found them very co-operative. On the question of selective oxidation, his firm were engaged at the present time in installing equipment abroad for the bright-annealing of brass tubes, and they had recommended that the brass used in this particular case should contain sufficient aluminium to give a protective film of alumina under selective oxidation conditions. They had used cracked and burnt ammonia but their main difficulty had been to obtain burnt ammonia having a sufficiently low dew-point to give satisfactory stain-free annealing. An atmosphere such as cracked ammonia was probably of a far lower dew-point than could be obtained by ordinary dehydrating methods. Mr. Lees had referred to cast brass. They had not done any work at all on cast brass, and could offer little comment on the points raised. In answer to Mr. Symonds's question, he was not sure that de-gassing at an earlier stage would be an advantage, if the view were accepted that the bulk of the gas evolved from the strip was introduced by impurities rolled into the surface. Mr. Jones had asked whether vacuum annealing was really necessary. The paper indicated that it was, because it had been found necessary in order to remove the gases evolved by the brass and leading to oxidation of the surface. Vacuum annealing presented no practical difficulties whatever. On the point of the oxidation of the brass in a nitrogen atmosphere being due probably to impurities in the nitrogen, the word "probably" had been introduced deliberately. The work reported in the paper, prior to that statement, had indicated that gases in the brass contributed to oxide formation and, in the nitrogen experiments, it was not certain whether the oxidising gases arose from the original nitrogen atmosphere or from the gases evolved from the brass itself.

(To be continued.)

Telephone Arrangements for Load Shedding.—To mitigate the effects of any load shedding which may be necessary during the coming winter, the Electricity Commissioners have asked the supply undertakings to consider whether their present arrangements could be improved by the installation of telephones at additional substations and load centres. It is understood that applications for such additions will be given a high degree of priority by the Post Office, although there can be no question of installing new exchange facilities at central control points before the coming winter.

THE INSTITUTION OF NAVAL ARCHITECTS.

As stated on page 303, *ante*, the autumn meeting of the Institution of Naval Architects was held at Portsmouth on September 23 and 24, and at Southampton on September 25 and 26, under the presidency of Admiral of the Fleet Lord Chatfield, G.C.B., O.M. Three papers were presented at each centre during the technical sessions, and we commence below a report of the proceedings at those meetings. The first paper, by Vice-Admiral L. V. Morgan, C.B., C.B.E., Admiral Superintendent of H.M. Dockyard, Portsmouth, gave "An Historical Review of Portsmouth Dockyard in relation to our Naval Policy."

Portsmouth Dockyard and Naval Policy.

Portsmouth harbour, said Vice-Admiral Morgan, had many advantages from the point of view of security, but there was no evidence that the Romans had paid much attention to it. After the Norman Conquest, the Channel became virtually an Anglo-Norman sea, but the loss of Normandy in 1204 forced England to develop into a maritime Power and the rise of Portsmouth dated from that time, though it was not until 1495, in the reign of Henry VII, that the first "dokke for the Kynge's shippes" was constructed—at a cost of 193*l.* 0*s.* 6½*d.* None of the ships of Henry VII was built at Portsmouth, however; this development was due to Henry VIII, in whose reign the Royal Navy began what proved to be an almost continuous expansion. During the reigns of the first two Stuart kings, the fortunes of the Navy and the Dockyard fluctuated considerably, but the Commonwealth saw the establishment placed on a reasonably permanent basis and, by the end of the Seventeenth Century, it had become the nation's chief naval centre.

The first steam engine was installed in the yard in December, 1797, and the first steam vessel to be built there—the paddle steamer Hermes—was constructed in 1835. The first screw vessel to be built at Portsmouth was H.M.S. Rifleman, in 1846; and the last sailing vessel, H.M.S. Leander, followed only two years later. During the Nineteenth Century, the Dockyard was greatly extended and now contained 14 docks, as well as four locks which could be used as docks on occasion; a fifteenth dock was permanently occupied by H.M.S. Victory. During the recent war the yard was mainly concerned with repairs and refits, but it was also the main naval base for the invasion of Normandy and built many of the components of the Mulberry Harbour. Vice-Admiral Morgan concluded his paper by quoting from one of the books of the late Professor Sir Geoffrey Callender a passage which, he suggested, it would be wise to remember: "A Navy (and, indeed, a Royal Dockyard) cannot be improvised any more than a garden. Both need unstinted time and care, and both can be ruined by a few years of neglect."

The discussion was opened by Admiral Lord Fraser (Commander-in-Chief, Portsmouth) who, after paying a tribute to the ingenuity and skill of the Royal Corps of Naval Constructors, observed that the last occasion when this country was successfully invaded was in 1066—and it occurred when England had no fleet. For 800 years, Britain had resisted invasion by means of the Navy; to-day that protection was given by the combined Services, but that would not be possible without command of the seas in order to bring in supplies.

Mr. R. W. L. Gawn said that the paper by Vice-Admiral Morgan showed that not only was naval history made at Portsmouth, but that it was still being made; it showed also that history was made in the realm of research and development. One instance which emphasised that was the impressive "gate-crashing" by the Turbinia at the Diamond Jubilee Review by Queen Victoria, 50 years ago. An observer on the Portsmouth foreshore might have seen recently another small craft proceeding at high speed in the Solent; similar to a motor torpedo boat, but conspicuous in that it was fitted with a funnel. The craft was the first in the Navy to be fitted with a gas-turbine engine. The observer might have reflected that this event was as pregnant with possibilities for the Navy as was the Turbinia 50 years ago.

Dr. G. S. Baker commented on the fact that Portsmouth contributed its first ship for the King's service so long ago as 1451, for carrying troops to France. Another matter which linked Portsmouth with the Institution was that, in the period 1500-1523, when there was a great increase of building in the Dockyard, the elder Peter Pett was employed there.

Mr. L. Woollard recalled that Portsmouth Dockyard was associated with the earliest attempt in this country to reach the science of naval architecture. The first school of naval architecture was founded in 1811; it had a short life, and a second school, founded in 1848, also had a short life. The school building became derelict and, in 1863, Scott Russell, in the Institution's *Transactions*, gave a picturesque account of the building, which was let to somebody for 60*l.* a year. A number of brilliant naval architects were trained there, however, and their influence had spread, leading finally to the creation of a third school at South Kensington, which was followed by the present naval architecture course at Greenwich. The school of naval architecture at Portsmouth had culminated in a tremendous development in the science of naval architecture.

Mr. W. E. Noble suggested that Vice-Admiral Morgan's paper should be published as a pamphlet and offered on every bookstall in the country, because the Dockyards, as well as the Navy, belonged to the people of Britain and it was very necessary that the people should take an interest in them. The great mass of the voters in the country should know something about the Dockyards. Papers on other dockyards might follow. Commenting on Vice-Admiral Morgan's reference to tradition and efficiency, Mr. Noble said that he would like to see a revival of the practice which had prevailed nearly 50 years ago, when he had entered the yards. In those days, a capital ship was built at each yard, and the spirit of competition permeated everyone, from the highest officials to the smallest rivet boy. Their Lordships had declared that they must keep the private shipbuilders going, but it was very necessary, also, to maintain the dockyards at the highest pitch of efficiency.

The President, in proposing the thanks of the meeting to Vice-Admiral Morgan, agreed that the paper would be of the greatest interest to the citizens of Portsmouth and hoped that it might stimulate someone to write histories of Devonport Dockyard and the others.

Effect of Blade Area on Propeller Cavitation.

The second paper, entitled "Some Model Experiments on the Effect of Blade Area on Propeller Cavitation," was presented by Mr. L. C. Bell, R.C.N.C., of the Admiralty Experiment Works at Haslar, and described the results of tests with a family of six three-bladed propellers, 12 in. in diameter and of destroyer type, carried out in the cavitation tunnel which was put into service at Haslar in 1942. The tunnel, Mr. Bell stated, had a working section 2 ft. square, with rounded corners, and was provided with large observation windows, flush on the inner surface. The model under test was driven by a 50-h.p. motor with electronic speed control, the thrust being measured by a weighing balance and the torque by an optical torsionmeter. The tunnel water was circulated by a screw impeller in the lower limb of the circuit, driven by a motor of 150 h.p., the water speed being measured by a manometer across the ends of a Venturi contraction. Pressure conditions in the tunnel could be varied by a connection to a large air vessel, which could be exhausted by a reciprocating pump.

The vortex character of the laminar cavitation was strikingly demonstrated by the experiments. The first appearance of tip vortex was entirely laminar, while root cavitation was normally of the "burbling" type. The two types frequently appeared together when the loading was sufficient to induce laminar cavitation over about half of the blade. It was possible, in the tunnel, to vary the absolute pressure at the propeller until laminar cavitation spread gradually over the back of the blade, with the screw under a constant working condition. As pressure was reduced, with the screw working at a constant J value, cavitation appeared first as a fine trailing vortex, which spread towards the boss. The slope of the load curve deduced from the tunnel experiments differed from that of the calculated curve towards the tip; further experiment, it was thought, might show a connection between blade shape near the tip and load distribution. It seemed reasonable to suppose that the diameter of the vortex core would be influenced by the boundary-layer conditions, and experiments to test this assumption showed that, with a roughened tip, the load being unaltered, the screw shed its vorticity in less concentrated filaments, with consequent reduced likelihood of flow breakdown. The appearance of tip vortices could be delayed by roughening the surface near the lips. The screws were run at speeds appropriate to the thrust required to propel a destroyer at 36 knots, but screw No. 1, of small blade area, proved unable to provide the required thrust under the conditions imposed.

Mr. R. W. L. Gawn, who opened the discussion, said that this was the first occasion on which a paper had been written dealing solely with the work in the cavitation tunnel at Haslar, although some results had been published in two lectures by Sir Stanley Goodall, to whom its construction was due. Before the war, a series of systematic investigations was planned, directed to the clarification of such items as propeller scale effect, air content of water, propeller-shaft inclination, cavitation in sea water, and methodical variations of propellers. Owing to war-time circumstances, a good deal of propeller research had to be deferred, but some progress was made, including a start on the tests described in the paper. The high duty had made it necessary for many model propellers to be made in manganese bronze to meet the requirements of strength and stiffness. The propellers were made to accurate standards, but it was found necessary to arrange for additional refinement in the finish of model propellers as a result of experience with the cavitation tunnel. One object of the experiments described was to obtain an accurate prediction of blade area of propellers of destroyers to ensure maximum propeller efficiency. An important consideration with H.M. ships was to combine good endurance at cruising speed with maximum full speed. The paper showed that, if the blades were narrow, good efficiency was obtained at low speed, but there would be a serious loss of full speed owing to cavitation. On the other hand, if the blades were wide, the effect of cavitation at full speed was reduced, but the propeller efficiency at low speed was then unfavourable and endurance was prejudiced. In one specific design the results showed that, if the blades were made narrow, the endurance at 20 knots could be increased by 7 per cent., as compared with wide blades, but there would then be a loss of full speed of fully 2 knots. The curves in the paper indicated that a moderate amount of cavitation could be accepted at full speed without prejudicing unduly the efficiency at cruising speed.

Mr. L. G. Stevens said that an important feature which emerged from the paper was that, at low cavitation numbers or at high slip, it was not possible to avoid serious cavitation loss, however low the pressure coefficient, if the blades were made too narrow. In such cases, mean pressure coefficient might be an entirely misleading guide. For the group of screws shown, cavitation was largely laminar in character, and, as the author had pointed out, due to vortex formation associated with the lift of the blade sections, rather than to the breakdown of suction on the back of the blade. Those considerations emphasised the real value of visual observations made possible in a cavitation tunnel. Without such information, the conclusion as to the inapplicability of pressure coefficient as a guide in certain circumstances might well be regarded as suspect, since burbling cavitation on the blade back would be expected to be closely related to pressure coefficient. The more complete understanding of the conditions under which a propeller was working thus formed a guide to improvement, quite apart from the quantitative data obtained from the tunnel. The nature of the agreement between the calculated

and the experimental thrust curve, although approximate, was encouraging. It appeared that it might be used to interpret the experimental results of detailed blade modifications and so enable the range of general propeller theory to be extended by the complementary contributions of theory and experiment, thus leading to improvements in propeller design.

Professor A. J. Sims, O.B.E., wished that it had been possible to obtain the maximum unital blade loading which had been found appropriate to the various propellers tried. Perhaps, with more data, it would be practicable to tell how much the criterion of 0·75 ton per square foot of blade area was departed from. The author had said that burbling cavitation was a likely source of erosion, and suggested that attention to root design and root fillets would enable burbling cavitation to be reduced considerably. There was a school of thought which considered that the reversible propeller was a necessary adjunct of the gas turbine when fitted to ships. It was known that such a propeller was almost certain to involve a slight loss in peak performance, and, apparently, it would be even more difficult in the reversible propeller to avoid burbling cavitation.

Dr. E. V. Telfer suggested that the author might apply the R. E. Froude tradition to some of his results and plot them to show the cavitation on the analysis pitch.

The author, replying to Professor Sims, said that it had been found that with any propeller, particularly on a destroyer, the root design was very sensitive indeed; for instance, on an experimental propeller, if there were a slight flaw in manufacture, burbling cavitation was the immediate result. Secondly, with the controllable root, root cavitation must be expected; and, on the same grounds, erosion. He believed that the manufacturers found that blades were much easier to make of stainless tseel if only one were made at a time. So far, there had not been much success in making large screws completely of stainless steel. Replying to Dr. Telfer, he said that the only thing in favour of the type of plotting used in the paper was its simplicity. A pitch factor must be obtained for any particular design. The face/pitch ratio was one parameter: if that were abandoned as a parameter, a more complicated method of plotting would be necessary.

The meeting was then adjourned.

(To be continued.)

The Royal Observatory: Errata.—We regret that some errors in our summary of the Astronomer Royal's report, published in last week's issue, on page 304, escaped notice. In the last line of the middle column, 10″ should, of course, read 10^{11}, and about half way down the third column the error in the longitude of Mount Stromlo should have been given as 0·103 sec. too far to the east. Chronometer was also wrongly spelt.

Zinc-Alloy Press Tools for Sheet-Metal Parts.—Messrs. Imperial Smelting Corporation, Limited, 37, Dover-street, London, W.1, advise us that they have had a description of "Blanking, Piercing and Forming Tools of Zinc Alloy for Sheet Metal Parts" reprinted and will forward a copy, free of charge, to responsible persons interested. The account, which is based on a paper presented by Mr. J. W. Sladen, A.M.I.P.E., and Mr. H. S. Walker, A.M.I.P.E., before the Sheet and Strip Metal Users' Technical Association, describes the method employed in the development of zinc-alloy press tools for the fabrication of sheet metal parts by the Bristol Aeroplane Company, Limited (Aircraft Division).

Machine Tool and Engineering Exhibition, London, 1948.—Some further information is now available regarding the Machine Tool and Engineering Exhibition, London, 1948, which, as stated on page 113, *ante*, is to be held at Olympia, London, W.14, under the auspices of the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1. The exhibition will be open from August 26 to September 11, 1948, both dates inclusive, and will display a comprehensive range of machine tools, woodworking machines, equipment and accessories. The three halls at Olympia have been taken, providing nearly a quarter of a million square feet of floor space. The exhibition will be international in scope, British and foreign exhibits being shown side by side.

LABOUR NOTES.

Several important aspects of the present rather confused industrial trouble were discussed by the General Council of the Trades Union Congress at their meeting last week. It was decided after consideration, to appeal to all affiliated unions to co-operate in the carrying out of the export programme announced recently by Sir Stafford Cripps, and, at the same time, to seek in a meeting with the Minister, more information regarding the working of the plan. They also discussed details of the Control of Engagement Order, and, in an official statement issued at the close of the meeting, it was declared that the Council had "emphasised the necessity of operating the provisions of the Order, and of using the powers of direction in supplementing the Order, with exceptional care and discretion." The General Council, it was added, would give further consideration to the matter of bringing within the scope of direction those who at present do no "useful work."

The general question of wages was also considered by the Council, and it was decided, it is understood, to seek an interview with the Prime Minister on the subject of a national wages policy. This is of course, a matter on which the affiliated unions hold decided views. The General Council has, in fact, on their behalf, expressed strong opposition to any Government interference with the free negotiation of wage rates between individual unions and the employers of their members, and a letter sent by Mr. Isaacs to a number of joint industrial councils is assumed in some quarters to be a challenge to that position.

In his letter, the Minister of Labour and National Service drew attention to the Prime Minister's statement in the House of Commons on August 6 in the course of which Mr. Attlee appealed to operatives "not to press at this time for increases of wages or for changes in conditions which would have a similar effect." A clear undertaking is sought by the General Council from the Government that there will be no interference with wages negotiations in the various industries, and fuller information will be asked for regarding the constitution and activities of the branch which the Ministry of Labour and National Service is setting up to collect facts about wage claims and their probable effects.

Addressing a conference of the Confederation of Management Associations at Oxford on Friday last, Mr. Isaacs, the Minister of Labour and National Service, gave details of a plan which will, in effect, re-establish a joint production committee in every workshop and factory doing essential work. The scheme, it was explained, has been drawn up by representatives of the British Employers' Confederation, the Trades Union Congress and the Government, and its effect would not be, it was claimed, to give workers an opportunity to take over management but to provide them with knowledge of the nature of the problems involved, and invite them to co-operate in a joint effort to solve them.

A delegate conference of the National Union of Furniture Trade Operatives, sitting at Blackpool last week, instructed the executive council to seek a "substantial increase" in all minimum rates of wages, the raising of women's wages from two-thirds to 85 per cent. of the current minimum rate for men, and a higher percentage of the adult rate for young workers. The executive council was further instructed to regard as fundamental aims the establishment of a 40-hour week without loss of wages, and an annual paid holiday of 12 days. At present, the members work a 44-hour week.

The Post Office Engineering Union has negotiated, with representatives of the Postmaster General, wage increases for various grades in the stores section. New rates for warehousemen range from 5*l.* 12*s.* to 6*l.* 4*s.* a week in London, representing a maximum increase of 12*s.* 6*d.*, and from 5*l.* 8*s.* to 6*l.* a week in the provinces, with a maximum increase of 11*s.* 6*d.* New rates for storemen in London range from 5*l.* 2*s.* to 5*l.* 8*s.* a week, and in the provinces from 4*l.* 18*s.* to 5*l.* 4*s.* a week. Packers and porters, store women, store boys, and watchmen are also to receive increases. The agreement is to begin to operate on January 1.

Between July 15 and August 12, the British official index figure for food prices dropped from 101 to 99; the decrease was mainly due to reduced prices for potatoes, other fresh vegetables, and apples.

The new minimum wage rates for employees in the retail food trades are to come into force on October 20. About 250,000 employees are affected. The revised minimum rates for managers in London range from 5*l.* 3*s.* to 8*l.* a week, and those for managers in the provinces from 4*l.* 19*s.* to 7*l.* 11*s.* a week. London manageresses get 4*l.* 8*s.* to 7*l.* 5*s.* a week, and provincial manageresses 4*l.* 4*s.* to 6*l.* 15*s.* a week. The new rates for men assistants, cashiers, van salesmen, and clerks are 4*l.* 16*s.* a week in London, and 4*l.* 12*s.* a week in the provinces; for women they are 3*l.* 10*s.* a week in London and 3*l.* 6*s.* a week in the provinces. The working week is reduced to 46 hours. Off-licences and fish and chip shops are included in the trades affected.

Last week's conference between representatives of the National Coal Board and representatives of the National Union of Mineworkers on the subject of increasing the working week failed to agree, and no arrangements were made for a resumption of the discussions this week. It need not be assumed, however, that such a meeting may not take place before these notes appear in type for, from every point of view, the matter is extremely urgent. At the earliest of the conferences to consider the matter, the Coal Board and the Union appeared to be well on the way to acceptance of the Mineworkers' proposal that the men at each pit should be left to decide for themselves whether they would work overtime in the form of longer week-day shifts or by an extra shift on Saturdays. The overtime was to be voluntary, but the miners' leaders undertook to see that a substantial amount was worked. It would be paid for at straight piecework rates.

The interruption of the negotiations is understood to have been due to the insistence of the Cabinet on acceptance of its plan to add an extra half-hour to the working day. Differences of opinion between the three parties concerned on important details also developed, and the union's representatives showed a strong disinclination to allow any interference with the operation of the Five-Day Week agreement. In some quarters, the Coal Board is blamed for giving effect to the Cabinet's views on the matter instead of exercising whatever authority the Nationalisation Act endows them with; but, obviously, they are in no different position in this respect from that of other employers of labour who cannot altogether ignore, in these difficult days, the views of the Government.

In his presidential address to the annual conference of the National Association of Colliery Overmen, Deputies and Shotfirers—which took place at Cheltenham last week—Mr. A. Macalpine said that the number of salaried officials who were being appointed to run the mining industry was accumulating fast. In 1935, when we exported 35,000,000 tons of coal to 56 countries, we had 15,000 salaried persons. To-day, when we were not exporting any coal, but importing it, there were 22,000 salaried persons. When we had 15,000, the cost of the salaries was 2½*d.* a ton; to-day, it was 1*s.* 8*d.* a ton. He did not say that all these salaried persons were unnecessary, but he was afraid that when they got down to revising the wage structure for sections directly engaged in the industry, they might be told that increases could only be given on increased production, because the money had been spent on big staffs.

The conference, by a majority, accepted the National Coal Board's offer of wage increases which include a maximum of 5*s.* a shift for colliery deputies, and, in the case of overmen, a suggestion that divisions should have power to pay each of them up to 100*l.* extra a year to maintain "superiority level." Mr. B. Walsh, the secretary of the Association, stated that, in the aggregate, about 2,500,000*l.* had been offered in wage increases.

The aims of the National Seamen's Union of China—which has a membership of 141,189, of whom 33,000 are in Shanghai, 13,000 in Canton, and over 10,000 in various foreign ports—were declared in resolutions adopted at a recent conference. The wages of seafarers engaged in the home trade, it was stated, should be adjusted so as to take into account the cost of living in the ports which their ships served, and the conditions of employment of seafarers serving abroad be those laid down in international agreements. Hours of work and manning scales should be fixed, contract labour be abolished, and employment and dismissal agreements concluded with various shipping companies. The Ministry of Communications should be asked to instruct the shipping authorities to protect the employment of seafarers by restricting the issue of licences, and the scope of the maritime unions be defined and membership of a union made compulsory. Training classes for seafarers should be established by the Union, and the Government be asked to provide unemployment relief for seafarers. Schools or supplementary classes for the children of seafarers should be established by branches of the Union.

HYDRO-ELECTRIC DEVELOPMENTS IN SCOTLAND.

Fig. 1.

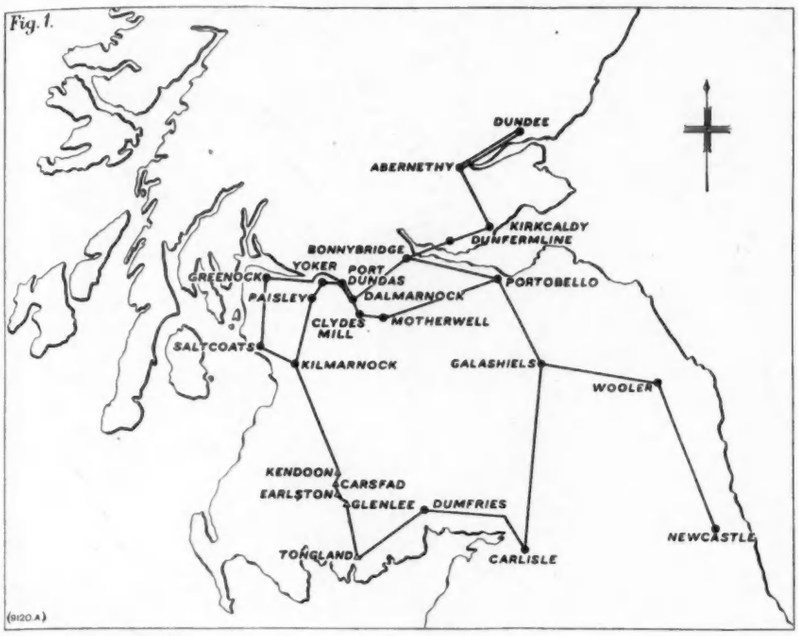


Fig. 2.

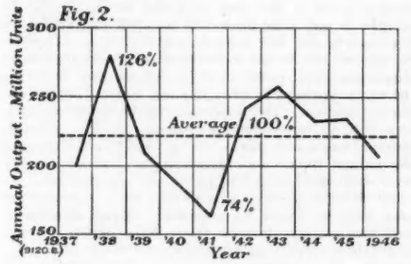
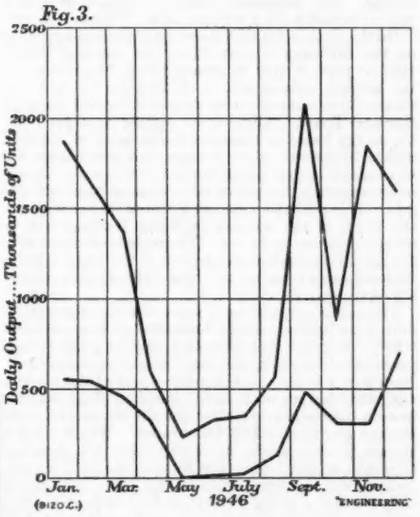


Fig. 3.



HYDRO-ELECTRIC DEVELOPMENTS IN SCOTLAND.*

By J. HENDERSON, M.C., B.Sc., M.I.E.E.

ALTHOUGH previous estimates had shown that the water-power resources in Scotland were extensive, only four schemes of any magnitude had been developed before the Electricity Supply Act of 1926. Of these, three, with an installed plant capacity of approximately 60,000 kW, were developed solely for the production of aluminium, while the fourth, on the falls of Clyde, having 15,520 kW of installed plant, was constructed to supply electrical energy to the Clyde Valley Electrical Power Company which, with its extensive distribution area near at hand, provided a ready market for all the energy produced from the time the plant was completed and ready for operation.

Only one other scheme was projected before 1926, and this has since been fully developed by the Grampian Power Company. Full operation was greatly assisted by the fact that when it was completed excess energy and power could be disposed of to the Central Electricity Board, thus providing an immediate return on the initial capital until the energy could be utilised fully in the area of the Grampian Company. The installed plant capacity is 90,000 kW, and the estimated average annual output in units generated is 285 million kWh.

It is generally accepted that the economics of water-power development demand an immediate market for the energy produced, or for a large proportion of it, owing to the heavy expenditure necessary on the civil-engineering side of the plant to enable future extensions to be made when required. The full utilisation of the water-power resources of any country is therefore determined by the commercial load requirements and the industrial development which has already taken place or may be possible in the future.

In 1926, it appeared that further exploitation of the water-power resources of the Scottish Highlands, on even a moderate scale, could only be carried out for chemical or metallurgical work located near the generation centres by manufacturing companies requiring a large amount of cheap electrical energy for production purposes. While such schemes, designed to meet specialised conditions of manufacture, would have been successful from a financial standpoint, they could have made only a limited contribution to the general electrification of the Highland area. This type of development, also, would have exploited only the most lucrative schemes and would have sterilised a large proportion of the national water-power resources which, although they would not have been developed as industrial units, might be integrated economically into a national system. The supply of cheap electrical energy for large-scale manufacture near the source of generation is, however, not precluded under the 1943 Act. This was designed to encourage the full use of Scottish water power primarily for industrial and domestic purposes locally, and if necessary for export to existing load centres.

The steam-generating station, subject to sufficient water being available for condenser-cooling purposes, may be built within a reasonable distance of the load centre, but the site of each proposed hydro-electric scheme is predetermined by the rainfall catchment area, the possibility of water storage and an adequate head of water for generation. By its nature, the parts of the country where conditions are suitable are sparsely populated and are a long way from the main load centres which have been determined in the past by other conditions. The small population in the hilly parts of the country makes it difficult for the energy generated to be absorbed locally, unless there is a transfer of industry and population to the surrounding areas. Taking other requirements into account it seems unlikely that such a transfer, or even the establishment of new industries, could occur within a period of time which would enable development on the largest scale to be remunerative.

It may be seen, therefore, that advocates of full-scale development of Scottish water power were faced before 1926 by an almost impossible task. On the electrical side, in addition to main transmission lines from the generating areas, the construction of an interconnecting network between the existing stations would have been necessary. This network, which proved such an asset during the late war, was constructed under the provisions of the 1926 Act for the interconnection of generating stations, and has made possible the full development of the water-power resources of Scotland. The immediate result of the construction of the grid was the Galloway hydro-electric scheme, whereby the whole of the water power in the south-western area of Scotland was developed and fully operated by the Galloway Water Power Company. The main grid lines on the west, interconnecting Central and South Scotland with North-West England, would have been erected in any case, but were constructed so that no main transmission lines were required by the Galloway Company. Fig. 1 shows how the 132-kV transmission lines of the Central Electricity Board interconnect the five Galloway generating stations enabling energy to be transmitted north to Central Scotland or south to North-West England. The Galloway scheme was constructed during the years 1930–36, and although the detailed costs of construction and operation of hydro-electric stations are beyond the scope of this paper, it may be stated that, due to the increased cost of coal, the considerable increase in the cost of erection of steam plant and the relatively low construction cost of the Galloway scheme, it has proved to be of great benefit to the country both financially and electrically. This is also true of the slightly smaller Grampian scheme, the benefits of which under the new legislation will accrue to the North of Scotland Hydro-Electric Board.

Before the construction of the grid it was general practice to make provision in each supply undertaking for plant capacity to cover the maximum load in any year with the largest generator out of action. This principle has been adhered to in settlements negotiated by the Central Electricity Board under the 1926 Act. With stations not interconnected this resulted in a very high percentage of spare plant, much more than was considered necessary after interconnection took place, when 15 per cent. standby was considered adequate. For steam stations the installed plant capacity is determined purely by the load conditions, and while these are never such that the whole of the plant can run at maximum efficiency, an operating programme where the number of hours run by each generator is dependent on the thermal efficiency obtains the best results under the prevailing load conditions. Subject also to the limitations of fuel supply and of breakdown, which are catered for by spare plant, a steam station can supply all the energy required and is in a position at any time to supply power up to the limit of plant capacity for which provision has been made.

While a water-power scheme might be designed to serve the same purpose and fulfil the same conditions of loading as a steam station, these conditions would require to be met under the most adverse circumstances of drought or frost, and such an arrangement would prove to be extremely wasteful of the potential energy available in a very wet year. Where steam plant is available for parallel operation, as it is in this country, the design of water-power schemes is freed from the limitations imposed by the normal load cycle. With steam and water complementary, and particularly where steam generation exceeds by a large amount that due to water power, arrangements may be made for the maximum utilisation of potential water resources at the minimum cost without the rigid limitations of load. It does not follow that there is no load limitation, but development and design may be pre-arranged to suit particular natural conditions to give the best economic return in any area.

It will be apparent that in this country, due to climatic conditions, the energy output may vary considerably from year to year and the power available from day to day. As an example, the output of the Galloway scheme is shown graphically in Fig. 2 for the ten-year period from 1937 to 1946. The annual output varied from a maximum of 279 million kWh in the very wet year of 1938 to a minimum of 163 million kWh in the dry year of 1941, or a variation from 74 to 126 per cent. of the average output over the ten-year period of 221 million kWh. The maximum and minimum daily outputs per month, excluding Saturdays and Sundays

* Paper read before Section G of the British Association at Dundee, on September 1, 1947.

for the year 1946, shown in Fig. 3, also indicate the wide limits of daily output possible in any year due to climatic variations. While minimum rainfall conditions usually occur in the summer period or during the six months in any year beginning in April and ending in September, the full output required from a hydro-electric scheme is not so essential as a complement to steam-generated power in these months as it is during the winter six months when the load demand is approximately doubled. It is important for the steam engineer, however, to have some knowledge of the probable output from water power over a yearly period so that the annual repair and maintenance programme may be co-ordinated with the generation programme. In order to meet the load at all times such co-ordination may only be based on minimum output conditions, and the energy derived from water-power sources under these conditions is generally referred to as "firm" energy. Any additional energy obtained in a wet year or period is often referred to as "excess" energy.

On the assumption that the worst conditions appeared on the Galloway scheme during the ten-year period 1937 to 1946, it may be assumed that 74 per cent. of the average output will be the lowest likely to be obtained from the schemes projected by the North of Scotland Board. Allowing an additional 5 per cent. for energy losses in transmission, a figure of approximately 70 per cent. of the average estimated output will be available as firm energy for delivery to the consumer or for export at the points of interconnection with the grid. It is probable that the figure of 70 per cent. for the whole of the schemes in North Scotland will be found in practice to be low. The periods of lowest rainfall are not coincident in all parts of the Highlands, so that estimates based on this figure will almost certainly err on the safe side.

The power output from a water scheme, particularly during the winter months, must also be guaranteed or "firm" in order that estimates may be made several years ahead for additional plant to meet a growing load. Firm power is not entirely independent of the rainfall, and other factors, such as the installed plant capacity in each hydro-electric station and the amount of water storage provided, affect the output. Where natural storage is not available in existing lochs it is necessary to create artificial reservoirs to meet the load requirements over any dry period of the year. The power output from a hydro-electric station without storage will vary with the rainfall and during a relatively short dry spell may be reduced to a very low value. An example of this is to be found in the "run of river" scheme in the Clyde Valley where, although the installed plant capacity is over 15,000 kW, the firm power ouput is as low as 1,000 kW.

In a "run of river" scheme, however, the installed plant is determined by the requirement that the maximum output in kWh should be obtained at flood or during times of heavy rainfall; and while this normally determines the minimum plant necessary on any individual scheme, the maximum installed capacity in a hydro-electric station will be determined largely by the part that station has to play in meeting the load requirements of the system of which it is ultimately to form a part, and also by the amount of storage which is available naturally, or can be created economically. It is also affected by the additional cost necessary for the larger-diameter tunnel and pipeline required for the supply of water for an increased capacity of generating plant. It is uneconomical to increase the size of the aqueduct where this is of great length; and stations which are required to meet peak loads only should be those where the storage is relatively low and where the tunnel is relatively short.

Over a wide area such as that covered by the North of Scotland Hyro-Electric Board the installed capacity of the plant must include a proportion of spare plant, and in all estimates it is usual to allow 10 per cent. of the total as spare. In addition, for delivery at any specified point, a further allowance must be made for transmission losses at full load, so that approximately 80 per cent. of the total installed plant in kilowatts may be reckoned as firm, assuming that other conditions governing the amount of plant required have been satisfied. As stated above, the main factor governing this is the part to be played by the hydro-electric station in the generation scheme, or, in other words, on the designed load factor of the station. The annual load factor of the combined industrial, commercial and domestic load in this country is of the order of 35 per cent. Although individual water schemes in isolated districts which are not interconnected with the general grid system may be designed for load factors of this order, it is unusual for such high values of load factor to be adopted for water stations acting as a complement to a large steam-generating system.

During the next five to seven years the North of Scotland Hydro-Electric Board propose to develop a limited number of areas, as shown in Fig. 4, providing stations having an installed plant capacity of 820 MW and a generated output of 2,300 million units. On the basis previously discussed this gives an output at the delivery point of 1,600 million units per annum and a power output capable of supplying a demand of 650 MW. The generated load factor for this section of water-power development is 32 per cent., while the load factor delivered is 28 per cent. Even these values are relatively high, but they have been loaded to some extent by some of the northern schemes which have been purposely designed for a high load factor with the object of catering for industrial concerns having a heavy annual consumption of electricity, and an almost continuous manufacturing process. It is hoped to attract such industries to these areas by offering favourable tariffs, as the energy supplied near the generation source does not have to bear the same transmission charges as energy exported to the south. Table I, on this page, gives details of some of the larger of these schemes, and it will be seen that the generated load factors vary from 11·4 per cent. in the case of Loch Sloy to 61·8 per cent. on the Glascarnoch scheme. Installations where the load factor is low are most suited to carry peak loads for short periods each day; and as the designed load factor becomes higher the station with the higher load factor is enabled to carry its maximum load for a longer period, or, alternatively, to give a greater output in daily units. A low load-factor station dealing with peak loads is in a better position to deal with excess water at times of abnormally heavy rainfall without waste of energy. The storage available also has a bearing on this question.

In order to discuss peak-load operation the daily load curves for the Scottish grid and the total grid loads are shown in Figs. 5 and 6, opposite. Fig. 6 shows,

HYDRO-ELECTRIC DEVELOPMENTS.

Fig. 4.

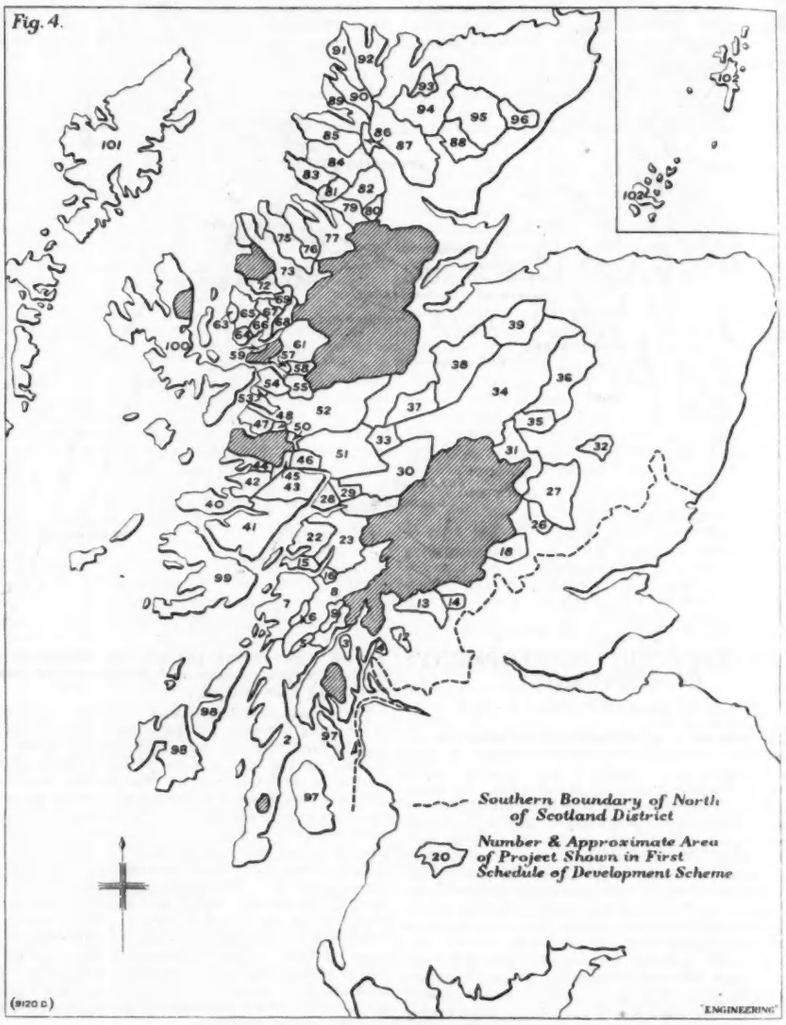

Southern Boundary of North of Scotland District
Number & Approximate Area of Project Shown in First Schedule of Development Scheme
20
(9120 c)
"ENGINEERING"

TABLE I.—DETAILS OF MAIN SCHEMES SCHEDULED FOR EARLY DEVELOPMENT BY THE NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.

Scheme.	Estimated Output, Million Units.	Installed Plant, MW.	Firm Output, Million Units.	Firm Power, MW	Annual Generated Load Factor, Per Cent.	Annual Delivered Load Factor, Per Cent.	Per Cent. Storage.	Storage, Million Units.	Daily Output, 70 Days Dry, Thousand Units.
Loch Sloy	130	130	91	105	11·4	9·9	15·4	20	272
Errochty	103	75	72	60	15·7	13·7	15·5	16	217
Lawers	67	20	47	16	38·3	33·5	17·9	12	163
Clunie and Pitlochry	197	72	138	58	31·2	27·2	19·8	39	530
Lednoch Earn ..	53	15	37	12	40·3	35·2	21·1	11·2	152
River Shira	80	44	56	35	20·8	18·3	21·2	17	231
River Lyon	206	65	144	52	36·2	31·6	21·8	45	611
Loch Quoich	350	80	245	64	50·0	43·8	25·2	88	1,195
Glen Affric	250	70	175	56	40·8	35·7	30·0	75	1,020
Glascarnoch ..	130	24	91	20	61·8	52·0	23·0	29·8	—
River Orrin ..	70	16	49	13	50·0	43·0	26·4	18·5	—
Tor Achilty ..	46	10	32	8	52·5	45·0	26·8	12·3	—
Loch Luichart ..	120	24	84	20	57·0	48·0	28·8	34·6	—
Loch Fannich ..	80	24	56	20	38·1	32·0	62·5	50·0	—
Loch Shin	140	50	98	40	32·0	28·0	—	—	—

HYDRO-ELECTRIC DEVELOPMENTS IN SCOTLAND.

Fig. 5.

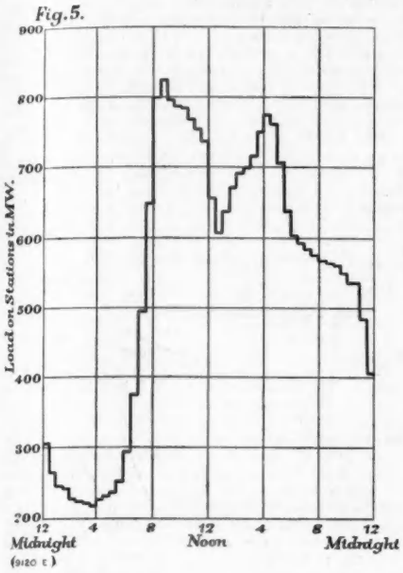


Fig. 6.

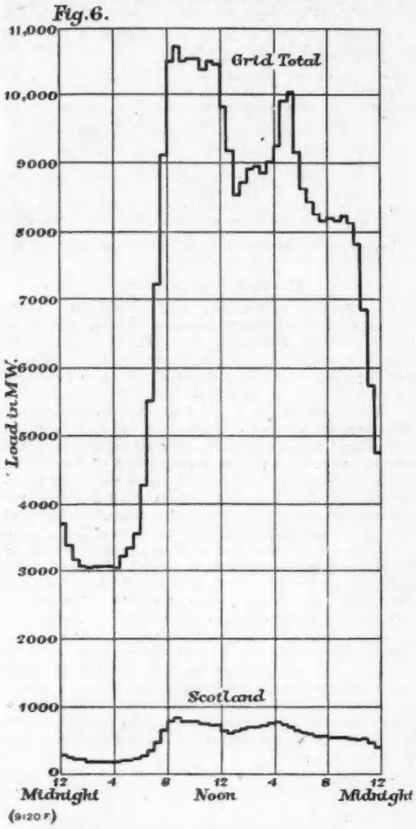


Fig. 7.

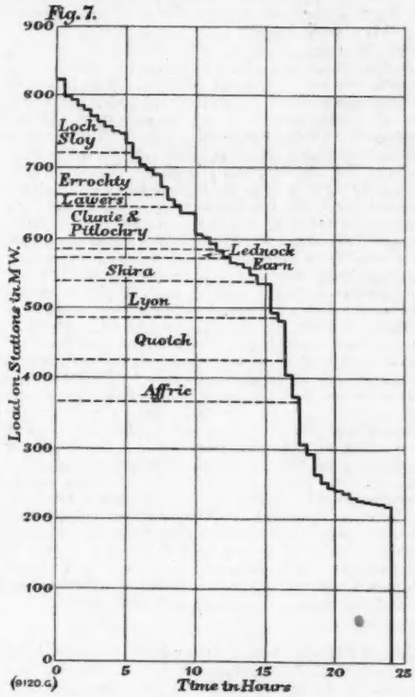


Fig. 8.

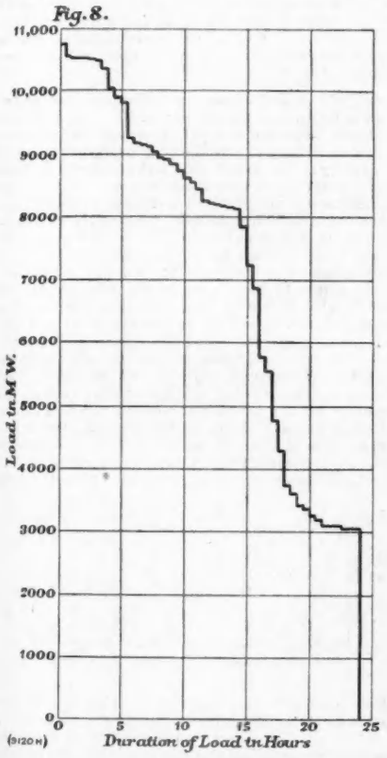
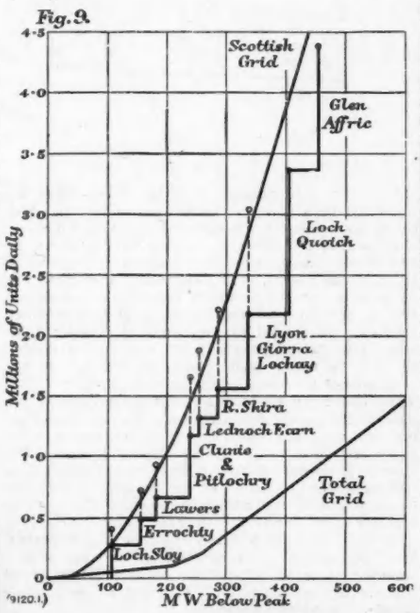


Fig. 9.



in addition, the Scottish grid load on the same scale. It will be seen that on the total grid load the opportunities for peak-load working with low load factor stations are much greater than in the case of the Scottish grid. As, however, this would involve heavy transmission south of the border it would appear to be more economical to use hydro-electric energy as near the source as possible. A more appropriate form of these load curves is shown in Figs. 7 and 8, where the same curves are given in the form of duration of load, showing the number of hours each day for each value of the load. While these curves represent the highest load obtained over the winter it is possible to have loads of peak order at any time during November, December and January. It is considered that in any dry spell during the winter a hydro-electric station should be capable of carrying out its minimum programme of generation or of giving its firm quota of kilowatts over a period of approximately 70 days without augmentation by rainfall. The ability to carry on generation over such a period in dry or frosty weather during the winter is entirely dependent on the number of potential units stored in the reservoir and available for use at times of drought. Figures for stored energy are also given in Table I for the larger schemes shown. Also included in this table are the number of daily units required from each station to meet such a 70-day programme. In Fig. 9, the duration of load curves have been integrated from the peak downwards for both the Scottish grid and the total grid loads, thus giving the energy required from the hydro-electric stations in kWh on a base of power in MW below peak. On the same scale, the estimated daily output from the series of stations shown in Table I to cover the suggested 70-day programme have been indicated. It seems obvious that, as designed, these stations, with the exception of Loch Sloy, are incapable of meeting such conditions on the existing load, and that if there were not change in the shape and magnitude of the Scottish load curve an export south of almost three quarters of a million units would be required each day. As it will be a few years before the construction is completed on many of the stations shown, it is probable that the magnitude of the peak will have increased considerably, with a consequent lowering of the integrated Scottish curve below the available output from the hydro-electric stations. As a matter of interest, the energy which can be supplied over a 50-day drought period is shown dotted in Fig. 9, and in each case the water available in storage is more than sufficient to meet requirements. A 70-day drought in the winter time is considered abnormal, but, if it is found in future that the hydro-electric scheme for the North of Scotland as a whole is incapable of meeting the guaranteed kilowatts in any dry year, it may be necessary to reconsider the idea of pumping during the night at Loch Sloy, or to make some other provision for supplying the firm demand made by the grid in Scotland. Loch Sloy is a scheme which is eminently suitable for night pumping. It was suggested by Mr. A. E. McColl, the present vice-chairman of the Hydro-Electric Board, in 1937, and a complete scheme for its development on these lines was considered by the Central Electricity Board at that time, but was not proceeded with. Pumping on a limited scale was also considered by the Hydro-Electric Board after the 1943 Act, but the idea has now been definitely abandoned. It is likely to be revived only in the event of difficulties being met with in the supply of the requisite power when necessary to meet the load.

(To be continued.)

ROLLS-ROYCE AERO-ENGINES.—Messrs. Rolls-Royce Limited, Derby, have recently published an interesting booklet which, under the title of *Rolls-Royce Achievement*, gives the history of the firm's contribution to aviation engineering. Beginning with Sir Henry Royce's design of the first "Eagle" engine, which dates from 1914, the development of later types is briefly, but effectively, recounted, including that which led to the winning of the Schneider Trophy in 1931. All the intervening types are described and handsomely illustrated, together with several of the aircraft in which they were employed, while a list of the records set up, 12 in number for the air, is given, bringing the history in this report down to September 7, 1946. Present-day conditions are referred to in the concluding paragraphs of the booklet, which relate to the firm's work in the jet-propulsion and gas-turbine engine field.

NOTES ON NEW BOOKS.

Sound: A Physical Text-Book. By Dr. E. G. Richardson. Fourth edition. Edward Arnold and Company, Limited, 41 and 43, Maddox-street, London, W.1. [Price 18s. net.]

Dr. Richardson's *Sound* is a well-known and widely used text-book of pass-degree standard. Though this fourth edition does not differ markedly from the third, some further material has been added and certain re-arrangements made in the presentation. It has not been possible to print references to all the original papers that have appeared in the interim, but a selection of the more important is given. Moreover, it is too early yet to include the work carried out during the second world war, but its extent can be gathered from the size of recent issues of the *Journal* of the Acoustical Society of America. The subjects treated include the velocity of sound, vibrating systems, longitudinal and torsional vibrations in solids, transverse vibrations of strings and rods, membranes and plates, vortex formation and jet tones, columns of air, analysis of sound, acoustic impedance, supersonics, subjective sound and technology. Mathematical developments have been kept as simple as possible throughout and physical aspects stressed. Certain topics in musical acoustics are not considered but these are dealt with adequately in other works, including one by Dr. Richardson himself. Technical applications receive the attention their importance merits. There are few misprints, but there is one glaringly obvious misstatement in the course of the deduction of the Sabine reverberation formula where, on page 303, the average value of cos δ, when δ lies between 0 deg. and 180 deg., is said to be $\frac{1}{2}$! The evaluation of the amount of energy falling per second on unit area of a wall bounding an enclosed space, throughout which the sound energy is in a completely diffuse condition, is a three-dimensional problem and by no means a difficult one.

Colliery Explosions and Recovery Work. By Dr. J. W. Whitaker, F.I.C., F.Inst.Fuel, M.I.Min.E., and Dr. H. L. Willett, B.Sc., Eng. (Min.), F.G.S., M.I.Min.E. Second Edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 12s. 6d. net.]

This book forms one of a series intended for candidates for certificates of competency, as managers and under-managers of mines, awarded by the Board for Mining Examinations. The series includes a volume dealing with mining law and mine management, but as it may be presumed that the National Coal Board, when they have had a few years in which to organise the complicated mass of previously-independent undertakings on a common basis, may introduce some system, more or less of a Civil Service type, for the selection of new entrants, it is possible that this volume dealing with mining law may have to be rewritten or extensively revised. The same remark, however, does not apply to the present volume, which is concerned entirely with technical matters. Problems of firedamp and coal-dust explosions, the treatment of gob fires and the organisation of rescue work will remain the same under any type of administration, except in so far as they are accentuated by more intensive methods of working and deeper pits. Greater outputs obtained by means of increased mechanisation, do not, however, necessarily involve an increase in the accident rate. Safety measures and growing knowledge have kept pace with the increased complexity of mining equipment and whatever may be the potential danger, mines in practice are continually becoming safer. It is the purpose of this book to furnish instruction on the strength of which that greater safety may be maintained. The early chapters cover fundamental matters and deal with the constitution of the air, the nature of combustion and similar basic considerations. It is stated in the preface that these chapters, apart from minor corrections, have not been altered in this second edition, but that later chapters dealing with such matters as the treatment of mine dust have been "modified considerably in the light of developments of the last fifteen years." This appears to be the only indication given of the date of the first edition, and as the preface to the second edition is dated December, 1944, the first edition, presumably, appeared about 1929. Since that time, investigations by the Safety in Mines Research Board and other bodies have greatly increased the information available on such matters as the nature of coal-dust explosions and the design of flame-proof apparatus. This information is, in large measure, incorporated in the later chapters, although the latest results contained in the reports of research bodies could not be utilised. This state of affairs, which is common to all text-books, has been accentuated by present publishing difficulties. The later chapters, however, give an adequate account of the present direction of development and furnish all that is necessary for the type of reader for whom the book is intended.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1938.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

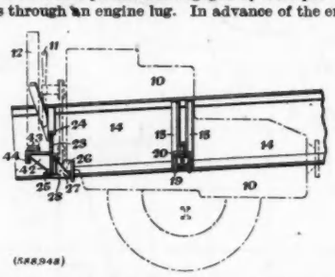
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MOTOR VEHICLES.

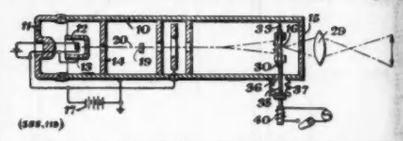
588,948. Engine Mounting for Motor Vehicle. Jensen Motors, Limited, of West Bromwich, Stafford, and F. A. Jensen, of West Bromwich, Stafford. (6 *Figs.*) February 7, 1945.—This invention relates to engine mountings for motor vehicles and its object is to facilitate engine replacement, thereby lessening the time during which the vehicle is immobilised due to mechanical breakdown of the engine. The engine and its accessories, exhaust system and the clutch and gearbox, are assembled together as a unit 10, the forward end of the engine being provided with a fan 11 arranged behind the radiator unit 12. Laterally projecting lugs are provided on the engine body somewhat to the rear of its centre of gravity. The longitudinal side members of the chassis frame are shown at 14 and on their inner sides next to the engine lugs are brackets 15 formed of spaced angle sections between the lower parts of which are secured channel-section brackets, these brackets being further secured by angles to a plate attached to the lower edge of the member 14. Mounted on each of the channel-section brackets is a U-shaped bracket 19, between which and the channel section is a rubber block. The member 19 carries a further bracket 20, which is of box-like form, and each of these brackets is provided with a nut retained in a pocket and engaged by a set pin which passes through an engine lug. In advance of the engine



unit the two side members 14 of the chassis frame are connected by a movable transverse member 23, which consists of a vertical web strengthened at the top by an angle section 24 and at the bottom by a further angle section 25. The top edge of this member 23 formed by the angle section 24, is of wide angled V shape. The forward end of the engine is secured to a U-shaped bracket 26 supported upon a rubber block 27, housed between, and bonded to, two supporting plates. The lower plate is extended at each end and is secured by bolts to a U-shaped bracket 28 attached to the rear side of the member 23 by angle brackets. The upper plate has welded to it a pair of upwardly projecting studs which engage openings in the bracket 26 and are provided with nuts which secure the bracket 26 to the upper plate and to the bracket 28. The ends of the member 23 are detachably supported upon angle sections secured to the inner sides of the members 14. On the forward side of the removable member 23 a pair of brackets 42 are provided, each of these brackets carrying a rubber block 43, on which the radiator 12 is supported. The brackets 42 are connected by an angle-section cross-bar 44, which is stiffened at the middle by an angle-section bracket to form a support for the starting handle. (*Accepted June 6, 1947.*)

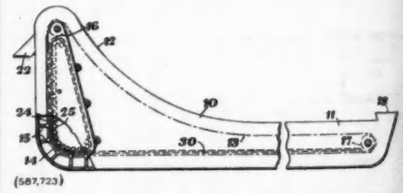
MISCELLANEOUS.

588,119. Electron Microscope. The British Thomson-Houston Company, Limited, of London. (2 *Figs.*) January 30, 1945.—The invention is an electron optical apparatus for the microscopic examination of objects pervious to electrons. An object may be microscopically examined by the rays of an electron beam passing through it, the beam in this passage picking up the characteristics of the object. The object of the invention is to overcome imperfect imaging due to lack of uniformity in the fluorescent screen. The electron microscope comprises an elongated vacuum-tight container 10 of tubular metal, at one end of which is a glass insulator 11 supporting an electron source consisting of a filamentary cathode 12. This is surrounded by a metal tube 13 which confines the emitted electrons to a narrow beam and co-operates with an apertured electrode 14, in contact with the envelope 10. The opposite end of the envelope 10 is sealed by a glass window 15 in front of which is a fluorescent viewing screen 16. The envelope 10 and the apertured elecrode 14 are maintained at ground potential and the cathode is maintained at a high negative potential, being connected to a battery 17 so that electrons emitted from the cathode are projected axially to produce a visible image on the fluorescent screen 16. Between the cathode 12 and the screen 16 is placed the object 19 to be examined. The electron beam 20, after passing through the object, passes through an electron lens system of the electrostatic type. The image formed on the fluorescent screen 16 is magnified by an optical



lens 29. The fluorescent screen 16 is held in a frame 30, which is suspended within the tube 10 by a set of springs 33, which provide a good conductive connection between screen 16 and tube 10. To one edge of the frame 30 is attached a rod 35, which extends through an opening 36 in tube 10 and passes through a bellows 37, which forms a seal across the opening 36. The rod 35 extends below the bellows 37 and is connected to a vibrator 40, which moves the frame 30 and screen 16 in a vertical plane at a frequency which is greater than the flicker frequency of the human eye, that is, at 20 or more cycles per second. Thus the effects of any holes or dirt specks in the fluorescent screen are minimised. Guides are provided to confine the motion of the screen to the vertical plane only. (*Accepted May 14, 1947.*)

587,723. Grain Conveyor and Elevator. Redler Conveyors, Limited, of Stroud, and C. W. Allin, of Stroud. (3 *Figs.*) January 9, 1945.—This invention is a grain conveyor and elevator in which the grain is carried along a trunk by means of an endless belt provided with flights. The objects of the invention are to enable the endless belt to negotiate bends and curves efficiently and to reduce the running friction of the belt. The conveyor consists of a casing 10 of sheet metal and L-shaped in side elevation, with a horizontal limb 11, and a vertical limb 12. Inside the casing 10 is an endless belt 13, composed of a number of chain links 14, each having an integral flight 15. The belt 13 is supported by a freely-running sprocket 16 at the top of the vertical limb 12 and from this sprocket the belt hangs and travels downwards along a curved path to a driving sprocket 17 near the free end of the horizontal limb 11. The internal space between the casing 10 and the tension belt 13 is fed with grain through a hopper 18. From the driving sprocket 17 the belt 13 passes through a horizontal trunk having an upper wall 30, towards the left and around a bend at the left-hand end of the trunk into an elevating trunk within the vertical limb 12. The latter has a discharge spout 22. Thus the grain



which is fed into the device through the hopper 18 is moved along the trunk by the belt 13 and its flights 15, and is carried up the elevator trunk, and discharged through the outlet spout 22 before reaching the sprocket 16. To ensure proper working of the layout, the friction of the moving parts is reduced as far as possible, especially where the jamming effect of the grain is greatest, at the bend and the elevator trunk. To reduce such friction and at the same time provide a compact arrangement, the bend and elevator trunk are both provided with a freely movable inner wall constituted by an endless flat band 24 of stout rubber strip. The band 24 is supported against the pressure of the belt 13 and the grain by a number of lateral rollers 25, which are spaced sufficiently close together to give the requisite support, at the same time enabling the belt 13 to run smoothly without bumping from one roller to the next. Near the upper end of the trunk the series of rollers 25 forms a curve below the sprocket 16, so as to lead the band 24 away from the belt 13 and on to its return run. At the lower part of this return run the band re-engages with the series of rollers 25, the first few of which are arranged in a curve directed upwards so as to lead the band smoothly into its run around the bend. (*Sealed.*)